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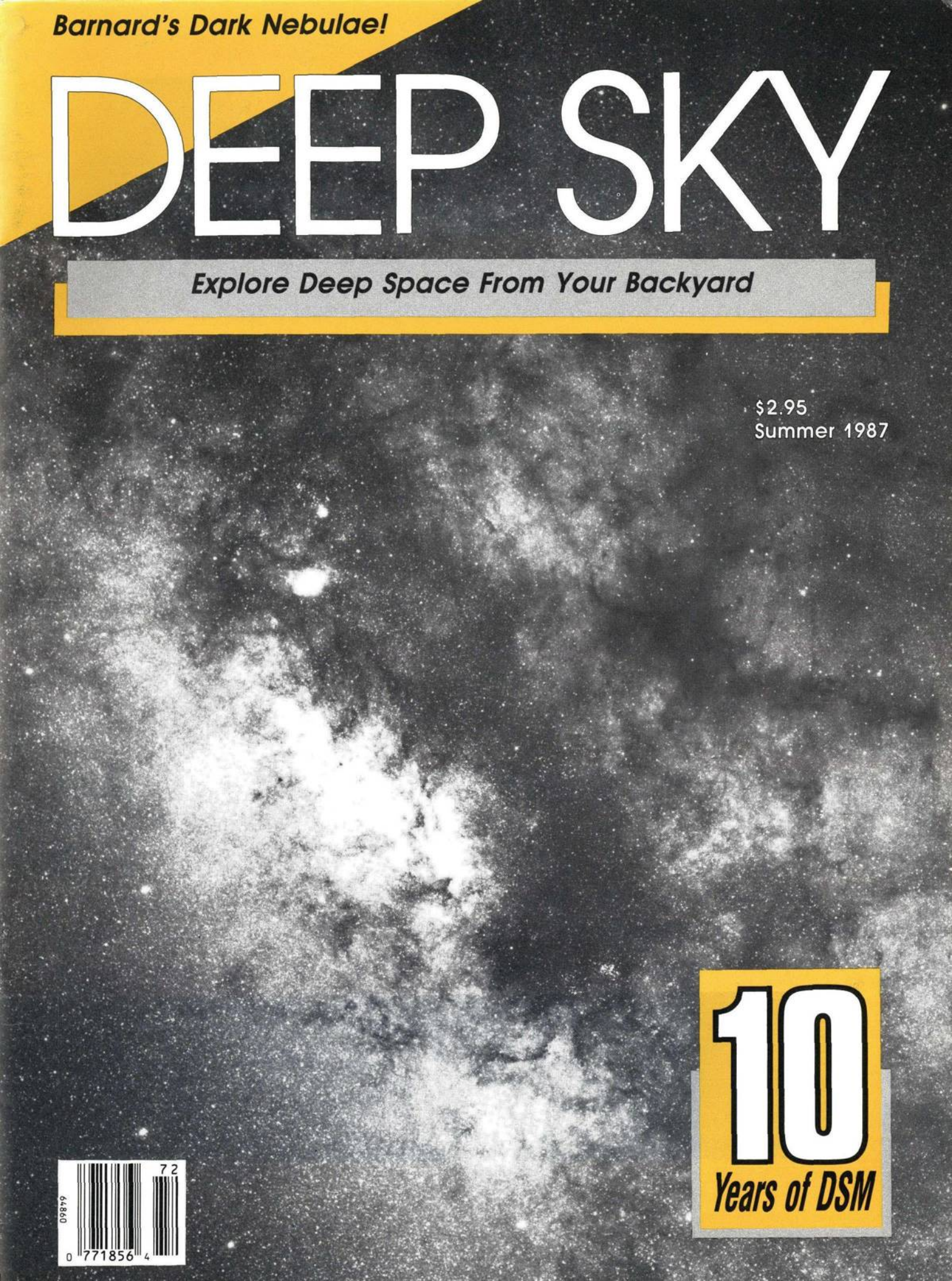

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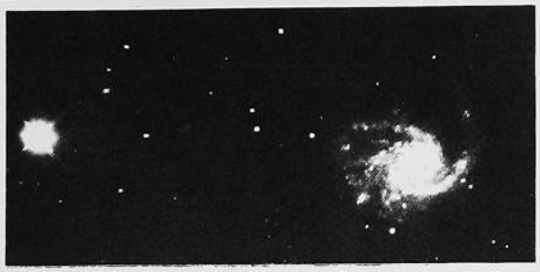

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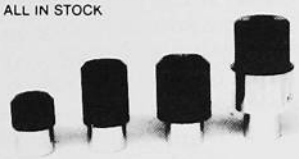

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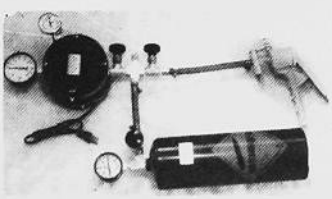

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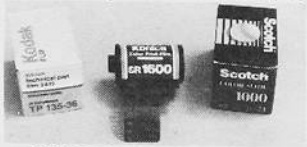

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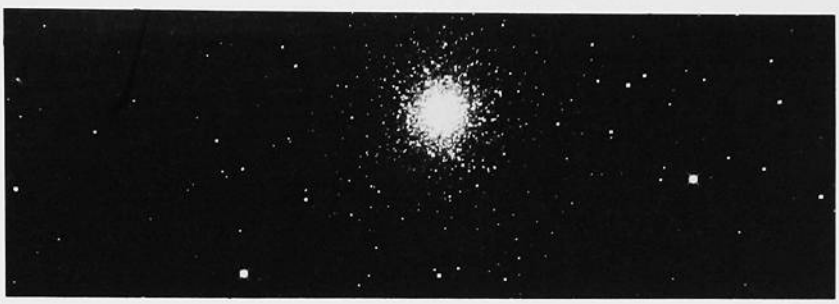
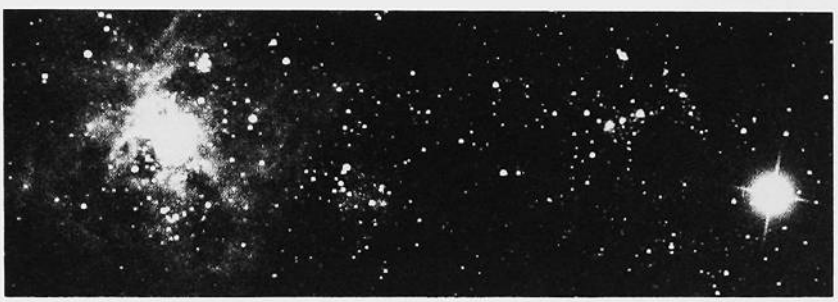


M13: King of the Northern Sky
by F. Michael Witkoski

6 *Hailed by northern observers as one of the sky's great showpieces, globular cluster M13's bright, easily resolved disk and favorable location in the Keystone of Hercules make it one of the most observed of all deep-sky objects.*



1987's Supernova in the Large Magellanic Cloud
by Richard Talcott

14 *Supernova 1987A became the brightest supernova since Kepler's in 1604 and is providing astronomers with invaluable information about stellar evolution.*

A Viewing Guide to E. E. Barnard's Dark Nebulae
by David Higgins

19 *Between the 1880s and early 1900s American astronomer Edwin Emerson Barnard made a landmark photographic study of the Milky Way. Many of Barnard's dark nebulae can be spotted with backyard telescopes.*

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AND ASTROPHOTOGRAPHERS

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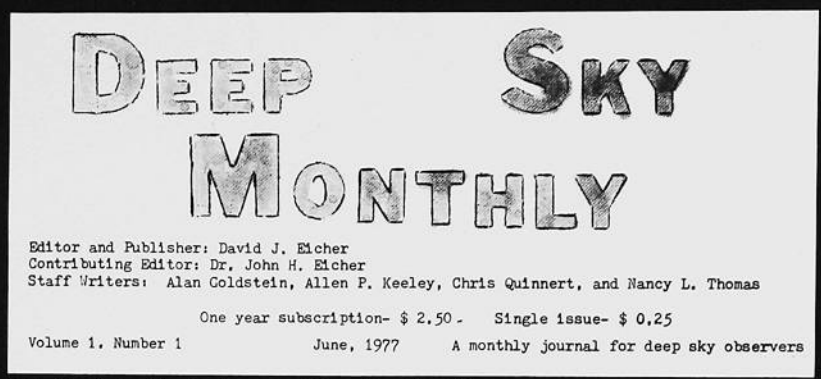
ON THE COVER: Dark nebulae abound in this photograph of the summer Milky Way by Alfred Lilge. Al used a 150mm f/5.6 Symmar lens with a red filter, 098-04 emulsion, and a 75-minute exposure. The shot was made from Palomar Mountain, California.

Inside View


DEEP SKY MONTHLY

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Volume 1, Number 1 June, 1977 A monthly journal for deep sky observers

Title block for the first issue of *Deep Sky Monthly*

I stood under the stars at the Texas Star Party and thought long into the night. A decade had passed. Ten years had swept by since my father and I cranked out the first issue of *Deep Sky Monthly* in his office at Miami University's chemistry department. Ten years had passed and I couldn't help thinking that in some ways it seemed like yesterday and in others it seemed like a century ago.

But together my dad and I produced sixty issues of *Deep Sky Monthly* between June 1977 and May 1982. Then, because of careful persuasion by Richard Berry, Astro-Media Corp. acquired *DSM*, made it a quarterly, and called it simply *Deep Sky*. This summer's edition of *Deep Sky* is the seventy-ninth issue of *DSM*. Since it marks the tenth anniversary of the magazine's inception and the fifth anniversary of *Deep Sky*, we thought we'd take a moment to celebrate.

Beginning on page 24, "DSM Reports" contains a group of three retrospectives about *DSM* and what trying to promote it was like. Alan Goldstein and Glenn Chaple, who wrote much of this section, are the ranking contributors to *DSM*, as some of you who read the magazine long ago already know.

Alan knew about the planning of *DSM* and was a contributor for the first issue. Glenn read the first ad for *DSM* in ASTRONOMY Magazine and became a contributor with the fifth issue.

Also in this issue is a detailed examination of M13, the Hercules Cluster. From the mail I've received over the years, M13 is a favorite for many *Deep Sky* readers. Mike Witkoski's article on M13 begins on page 6 and covers observational and astrophysical questions about the Great Cluster in Hercules.

You've undoubtedly heard lots of information and speculation on supernova 1987A in the Large Magellanic Cloud. Is it a Type II object? Does it represent a unique, previously unknown type of supernova? What will the long term ramifications be on our knowledge of the Galaxy and the space around it? ASTRONOMY's Rich Talcott provides an up-to-the-minute report on the LMC supernova in an article beginning on page 14.

With this issue I have the privilege of welcoming a new contributing editor, David Higgins of Krebs, Oklahoma. David is a co-founder of the Okie-Tex Star Party, has helped organize the Texas Star Party for the past two years, is central coordinator of the National Deep Sky Observers Society, and is an expert observer, specializing in dark nebulae. David's first article outlines many of E. E. Barnard's finest dark nebulae in the summer and fall sky.

I hope that these articles constitute a satisfying tenth anniversary issue. And I hope that during the next ten years *Deep Sky* will continue to evolve and provide the best deep-sky coverage possible.

Yours truly,

Dave Eicher
Editor-in-Chief

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M13
King of the Northern Sky

by F. Michael Witkoski

Hercules is the fifth largest group of stars, covering 1,225 of the sky's 41,259 square degrees. Although it contains no 1st- or 2nd-magnitude stars, it is rich in stars of 3rd, 4th, 5th, and 6th magnitude. Among these are Alpha Herculis, or Ras Algethi, a reddish variable that is possibly the largest star visible to the unaided eye, and Delta Herculis, a fine example of a "line-of-sight" or optical double. Telescopic objects include a few planetary nebulae and dim galaxies, as well as the globular clusters M92 and NGC 6229.

The heart of the constellation is the "Keystone," an asterism consisting of the 4th-magnitude star Epsilon Herculis and the 3rd-magnitude stars Zeta, Eta, and Pi Herculis. One third of the way from Eta to Zeta lies a special object that hypnotically draws our gaze, the globular cluster M13, also known as the Hercules Cluster. High in the sky during warm months, this spherical assemblage of seemingly countless stars has undoubtedly captivated as many novices as has any other deep-sky attraction. Its tiny specks of light nicely bunch into a telescope's field of view, and to a keen, unaided eye it is visible as a dim "star." M13 so dominates northern observers that the name "Hercules" implies the cluster as well as the constellation, an honor otherwise bestowed upon such conspicuously visible naked-eye luminaries as the Orion Nebula and the Andromeda Galaxy.

M13 as it appears through a small telescope. Photo by Dave Eicher, who used an 8-inch SCT at f/5, 103a-F film, and a 15-minute exposure. **Opposite page:** *Superimposed on this 5-meter Hale telescope photo are photometric V magnitudes (in tenths) for stars in M13 and two bright field stars. Photometry by Halton C. Arp and Harold L. Johnson using the 60-inch and 100-inch telescopes at Mount Wilson. Palomar Observatory photograph.*

The Nature of M13

M13 is a fine example of a globular star cluster, one of two very different types of star clusters inhabiting galaxies like ours. Globular clusters are large, uniform collections of stars, and only 154 are known within our Galaxy. Open clusters number in the thousands and hug the plane of the Milky Way.

Open clusters contain as many as several hundred stars, but globular clusters can hold hundreds of thousands of stars. Estimates of over a million are not uncommon for some globulars. Open cluster stars are generally massive, which compels them to evolve and burn out relatively quickly. Some survive for only a few tens of millions of years, a brief life indeed compared to the globular clusters, which have existed for at least 12 billion years. Of all known open clusters the oldest are Melotte 66 in Puppis and NGC 6791 in Lyra, both 6.3 billion years old. More typical for open clusters is the well-known Pleiades Cluster, which is approximately 78 million years old.

A globular cluster epitomizes celestial stability. Most globulars are a significant fraction of the age of the universe itself. As time passes the Galaxy will evolve: bright, profligate stars will rise and die young, the Galaxy's spiral arms will slowly revolve, a kaleidoscope of change will unfold beneath the grand halo of globular clusters, but they will endure, changing little as they exist through countless millennia.

Individually, globulars resemble swarms of luminous dots. Some are elliptical, but most are spherical. Although their concentrations vary, as outlined in twelve classes assigned by William Herschel, the major differences we observe from cluster to cluster reflect the varying distances from us to the clusters. Typically, the 100,000 to 1,000,000 stars fill a sphere 30 to 75 parsecs in diameter. None of the cluster's stars is overwhelmingly luminous because of its advanced age, but an occasional bright foreground star may create this illusion. Yellowish stars of spectral type F5 are close to the norm, and interstellar gas and dust are almost nonexistent within or near globulars.

Geometry seemingly tells us that a globular 30 parsecs across has a typical density of one star per 3 cubic parsecs, not appreciably different from the density of the Sun's neighborhood. Only near the center of the cluster would the stellar density far exceed that of our neighborhood: there it could be as much as three hundred times as great.

Globulars orbit the galactic center along highly elliptical paths. On the average, one revolution takes 300 million years. Kepler's laws of motion keep the clusters near the fringe of the Galaxy most of the time, but those exceptions with paths that come close to the Galaxy's central region lose some outlying stars each time through. Distant globulars, those avoiding gravitational tugs from the Galaxy, are therefore among the largest. The most distant is Palomar 3, a giant globular over 110 parsecs across lying 101 kiloparsecs away.

The distribution of the globular clusters in our sky is significant. Forty-nine of the 105 NGC globulars inhabit the

Facts about M13

Designation
Messier 13
NGC 6205

Position
right ascension: 16 hour 41 minutes 42 seconds
declination: +36 degrees 28 minutes
(coordinates are for epoch 2000.0)

M13 lies in the "Keystone" of Hercules, 2.5° south of the magnitude 3.5 star Eta (η) Herculis and some 30′ southwest of the magnitude 11.6 galaxy NGC 6207.

Magnitude
V magnitude of cluster: 5.86

The brightest cluster stars are 12th-magnitude objects. M13 is the fifth brightest globular cluster.

Diameter
apparent diameter = 16.6′
linear diameter = 37 parsecs

M13 has the tenth largest apparent diameter of a globular cluster; in physical size it ranks twenty-third among known globulars.

Distance
distance from Sun = 7.7 kiloparsecs
distance from galactic center = 9.3 kiloparsecs

Though M13 is relatively nearby, thirty-seven other globular clusters lie closer than or as close to the Sun as M13.

Variable Stars
M13 contains ten known variable stars, three of which are RR Lyrae stars.

constellations Ophiuchus, Sagittarius, and Scorpius. From this Harlow Shapley deduced in 1914 that the Sun lies far from the galactic center. Since then much evidence has confirmed his finding, although refinements and adjustments to the scale of the Galaxy have been necessary.

Other galaxies similarly house families of globular clusters. M31, the Andromeda Galaxy, is host to at least 355, while a retinue of eight accompanies its satellite NGG 205. The brightest in M31 lies at 13th magnitude, while in NGC 205 the brightest is a magnitude 14.9 object. A bit closer to home is the interesting case of the Fornax System, a dim dwarf galaxy about 170 kiloparsecs distant. The galaxy itself is almost impossible to see, but it contains five globular clusters of magnitudes 12.9, 13.7, 13.9, 14.1, and 16.6, all visible through amateur telescopes of suitable aperture. At our galactic doorstep are the Large and Small Magellanic clouds, which contain at least sixty (LMC) and fifteen (SMC) globulars, the brightest glowing at 10th magnitude.

Traveling beyond the Local Group, we encounter thousands of other galaxies, all potential homes for families of globulars. The gravitational hub of the Virgo Cluster, the giant elliptical galaxy M87, holds at least four thousand clusters.

The stars in globular clusters belong to a class known as Population II. Their characteristics are low mass, advanced age, and a small (about 0.1 percent) content of metals. Population II stars that don't belong to globulars commonly reside in the galactic halo and, like globular clusters, follow highly inclined elliptical orbits. Population I stars, on the other hand, differ greatly from Population II stars. Their metal content is at least 1 percent, and their orbits are roughly circular. The Sun is a Population I object, and so are open cluster stars.

Related in appearance to globular clusters but about ten times more massive are dwarf galaxies, a type of object not discovered until 1937. Their stellar content is distinctly Population II. A giant version of this type of object, M87, has a preponderance of Population II stars. Probably, it isn't too far from reality to whimsically consider M87 a supergiant globular cluster — despite the four thousand "normal" globulars surrounding it.

Another connection between globular clusters and giant elliptical galaxies is x-ray emission, which had been detected primarily in the late 1970s by NASA's orbiting *Einstein* Observatory.

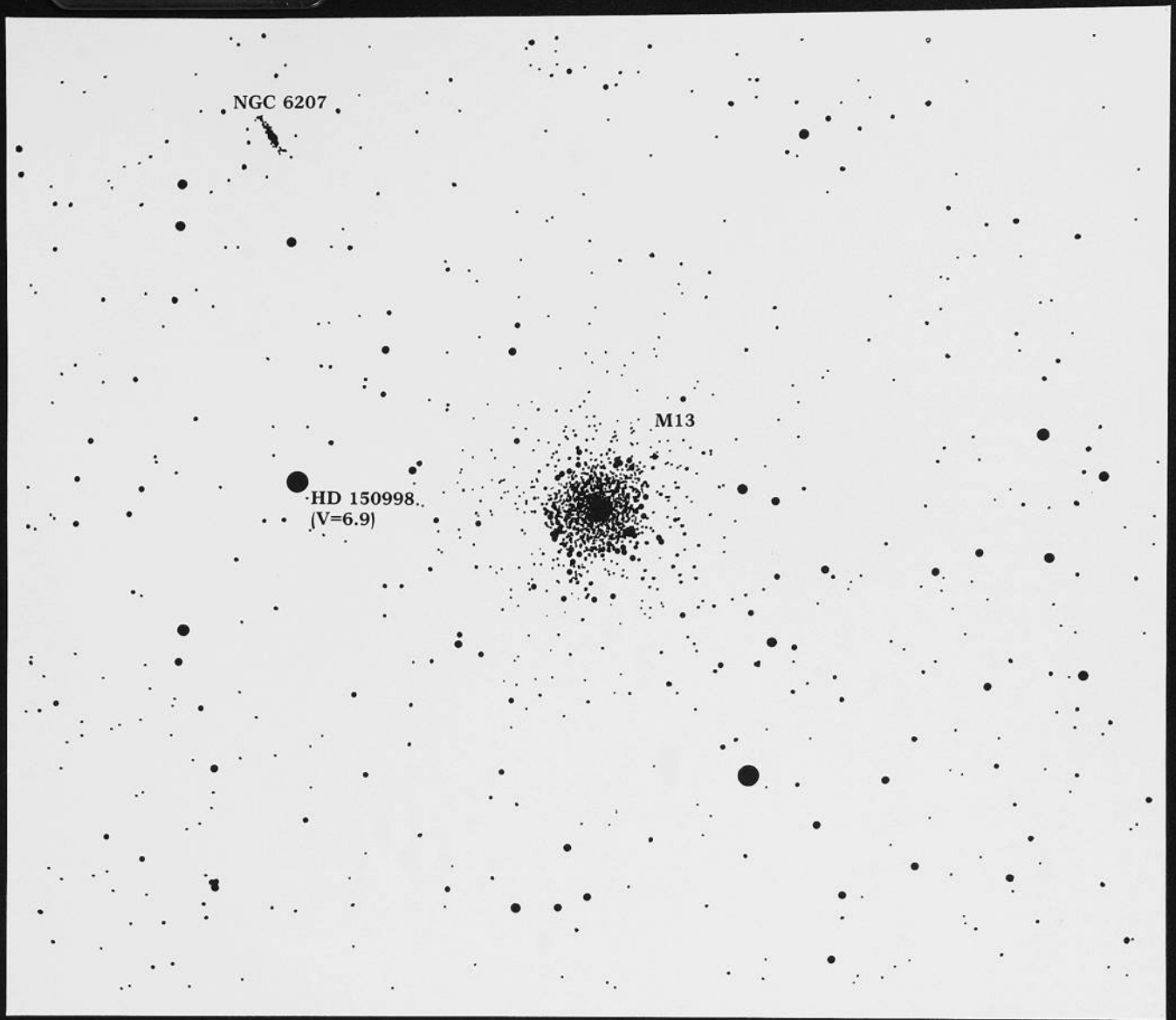
Observing the Hercules Cluster

Although it is a typical member of its class in absolute terms, M13 is the fifth brightest globular in our sky. Its total light equals that of a magnitude 5.9 star. Omega Centauri, the brightest globular, is an easy naked-eye target man has known about since antiquity. Only M22 in Sagittarius and M5 in Serpens, both more or less comparable to M13, were discovered before M13. (M22 was found in 1665 and M5 in 1702.) Apparently M13 was first telescopically seen in 1714 by Edmond Halley.

The epoch 2000 coordinates for M13 are 16h41.7m (R.A.), and 36°28′ (Dec.). M13's distance from us is 7.7 kiloparsecs, a little less than our separation from the center of the Galaxy. Other globulars are closer. Omega Centauri is 5.5 kiloparsecs away and NGC 6397 in Ara is a mere 2.3 kiloparsecs away. Among the most distant globulars easily visible in amateur telescopes is NGC 2419 in Lynx, some 90 kiloparsecs away.

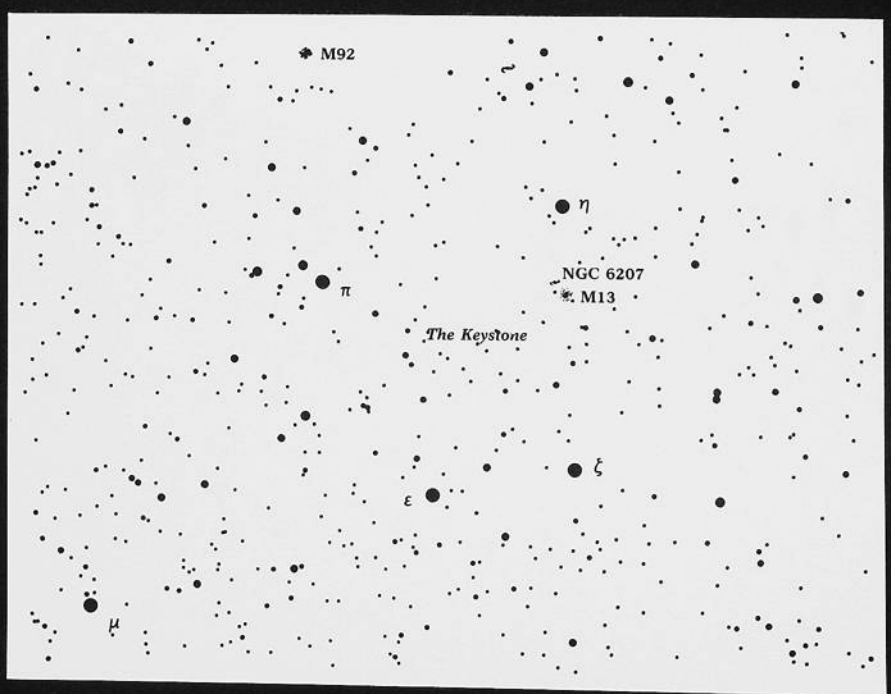
Any optical aid will reveal M13. Small binoculars or finder scopes will show a fuzzy point of light contrasting with pointlike neighboring stars. M13 is definitely not visible without optical aid under less than a very dark sky, and even then claims must be weighed carefully, because of two 7th-magnitude stars — also at the naked-eye limit — each less than 30′ away.

The true splendor of M13 is best revealed telescopically. Ideally, one should use a minimum aperture of 4 inches. Small refractors or large binoculars show a large, bright smudge, but resolution of individual stars is difficult. With a 4-inch telescope stars at the cluster's edge begin to show as individual points, and with a 6-inch aperture their images are strong and steady. As one steps up to 8- and 10-inch instruments, the size of the cluster swells a bit, and the clarity of individual stars closer to the center increases. M13 is a Class V globular cluster in Herschel's scheme, where Class I represents extremely rich specimens and class XII represents loose aggregations. Nevertheless, reso-



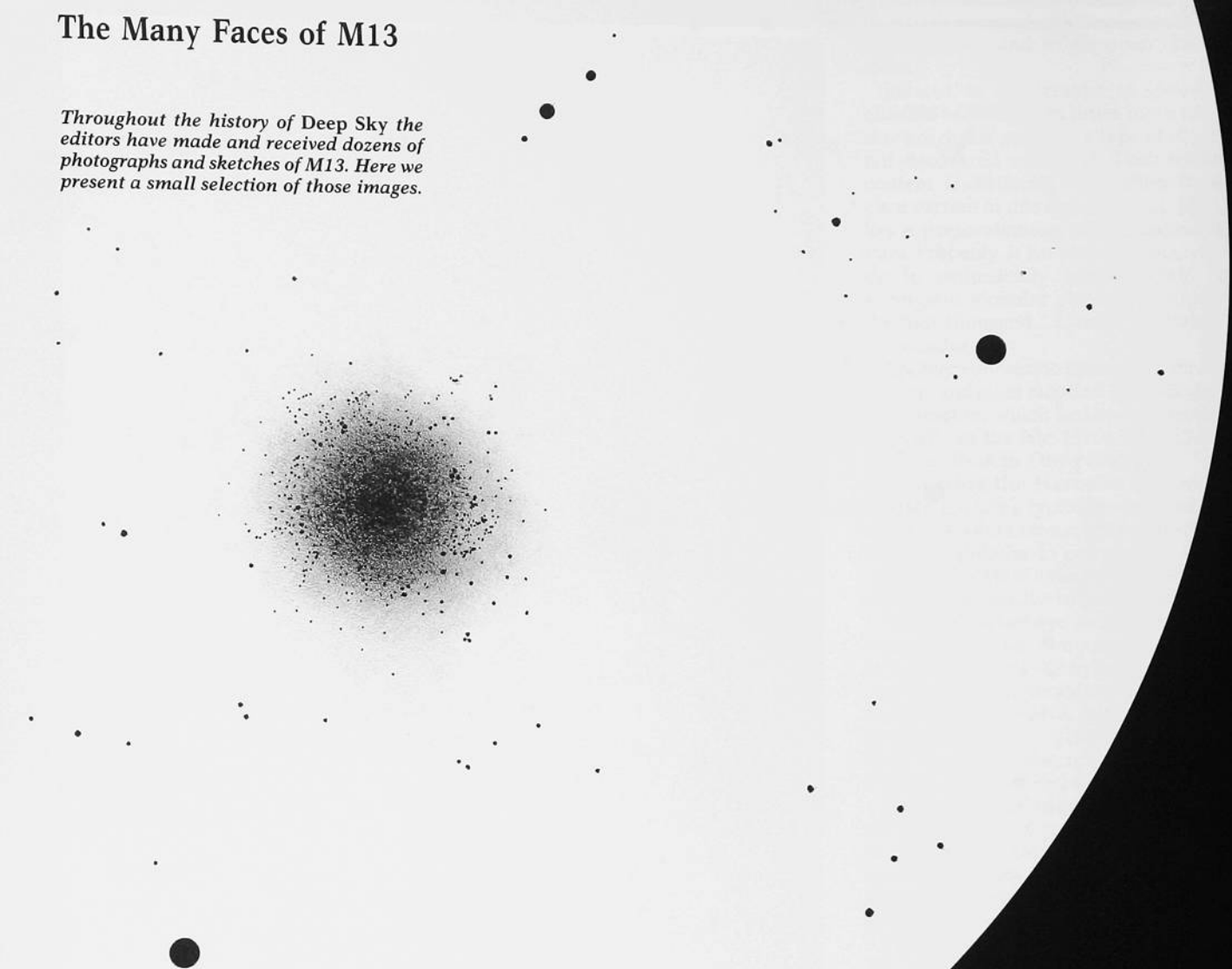
Zeroing In on M13

One of the factors contributing to the great popularity of M13 is its conspicuous location. The so-called Keystone of Hercules (right), one of the brightest asterisms in the northern sky, is all you really need to find. Point your finder scope toward Eta (η) Herculis, the northwest star of the foursome, and move the telescope south by 2.5°. M13 should appear in your telescope's field of view (above). Note the 30′ northeast of the cluster's center is the faint spiral galaxy NGC 6207. North is at top and east to the left in these maps made by Dave Eicher.



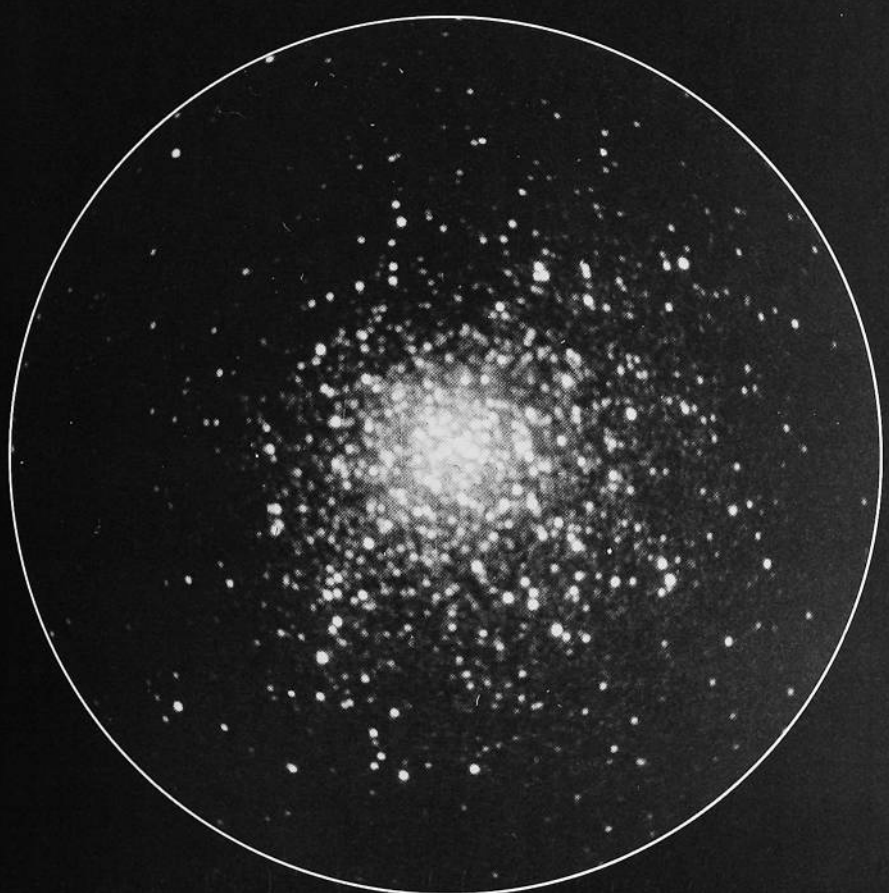
The Many Faces of M13

Throughout the history of Deep Sky *the editors have made and received dozens of photographs and sketches of M13. Here we present a small selection of those images.*



Above: ***M13 sketched with a 17.5-inch f/4.5 reflector at 71x. Drawing by Dave Eicher.*** **Below left:** ***Howard F. Zeh used a 14-inch f/11 SCT to record this image on 103a-F film. The exposure lasted 45 minutes.*** **Below:** ***Jack Newton made this photo with a 16-inch f/5 Newtonian, a cold camera, and a 12-minute exposure.***

Above: ***Jamey Jenkins obtained this image with a 6-inch f/4 reflector and Plus-X film.*** **Left:** ***This photo was made by Jack B. Marling, who used a 14.25-inch f/7 Newtonian, hypersensitized Tech Pan film, and a 14-minute exposure.*** **Below left:** ***Andy Sauletis made this image using a 16-inch f/5.6 scope, Tri-X film, and an 8-second exposure with a single-stage image tube.***



lution of the bright core of M13 is nearly impossible.

Somehow the task of tabulating individual stars in a globular cluster seems overwhelming, but William Herschel counted 14,000 in M13. A photographic survey at Mount Wilson identified 30,000 individual images. The total population of about one million is an estimate, of course. In contrast, consider the sparse globular NGC 5053 in Coma Berenices. It measures 10.5′ across, but it contains only 3,400 stars brighter than magnitude 21. A 12.5-inch telescope shows a scatter of a few dozen very dim stars spread across this cluster's tenuous disk. For further contrast, check the bright open cluster M11. Superficially resembling a globular, it contains about five hundred stars visible through a 10- or 12-inch telescope.

M13 is round, but all globulars aren't. The best example is the oblate cluster M19 in Ophiuchus, but the sky's brightest globular cluster, Omega Centauri, is also distinctly ovoid. Further individuality expresses itself in apparent arcs of stars streaming outward from the edges of the bright, dense regions of certain clusters. With M13, as well as with M3 in Canes Venatici and M5, averted vision seems to highlight these apparent tendrils through a 6-inch or larger telescope. Such streaming is not visible in any but the brightest globulars.

Also visible in M13 through 6-inch and larger instruments are dark patches against the disk of the cluster. The cause is probably intervening interstellar matter. The elliptical galaxy NGC 185,

This photograph shows M13 resolved into hundreds of stars and suggests a view through a large backyard telescope. Photo by Leo C. Henzl, Jr., who used a 14-inch f/11 SCT, Tri-X film, and a 20-minute exposure.

a dim satellite to M31, also shows similar obscuration, but only on photographs taken through large telescopes.

Variable stars in M13 are scarce. There are four RR Lyrae, three long-period Cepheids, and a few pulsating, ruddy Miralike stars. At the other end of the scale is M3, which contains at least several hundred variables.

In 1974 M13 was chosen as the target of a message transmitted by astronomers at the Arecibo Observatory in Puerto Rico. The hope was that an intelligent civilization somewhere inside M13 may someday intercept it. Why was M13 chosen? Obviously and deservedly, it is a very popular deep-sky object.

Why M13?

The reasons for M13's standing are many. M13 is easy to find. The straight line north-south configuration of its close reference stars in the Keystone could not be more convenient. Also, the Keystone itself is midway between Vega and Arcturus, the two brightest stars in the northern sky. Now consider the locations of M3 and M5. M3 lies practically midway between Arcturus and 3rd-magnitude Alpha Canum Venaticorum but 12° diagonally from both. M5 is about 11° due north of Beta Librae. Neither cluster is an instant find. M22 shares the same wide field with Lambda Sagittarii, and M4 in Scorpius is immediately west of Antares. Here we have two clusters with reference points better than M13's, but these clusters hug the horizon from northern latitudes during the summer months. On nights when they bathe low in murk and humidity, M13 is close to the cleaner, clearer zenith. Omega Centauri and 47 Tucanae are almost unknown to many northern observers. While Omega is visible just above the horizon in spring, 47 Tucanae is seen only from the tropics and the Southern Hemisphere.

To bolster M13's nearly ideal location, the cluster is also visible much of the year at convenient times of night. In late summer and fall, as it sets four minutes earlier each successive evening (as do all stars and clusters), the Sun also sets earlier. As the nights lengthen, M13 continues to grace us with its presence.

In springtime the opposite occurs. As the Sun sets later each evening, the stars and constellations, setting earlier to begin with, seem to change their positions very rapidly at first darkness from night to night. Such fine objects as the Virgo galaxies suffer from this.

Neighbors

If your telescope is 6 inches or larger in aperture, you will see a second deep-sky object in a wide field of view with M13. It is the faint (11.6 magnitude) galaxy NGC 6207, 30′ northeast. Telescopically it is a featureless object, but photographs reveal its spiral form. While it is only about 1/1,000th as bright as M13 (as seen from Earth), in absolute terms it is about 20,000 times as bright, and 140 times as distant. Chances are that systems similar to M13 surround NGC 6207. If they do, however, they would barely be distinguishable from grains on a photographic plate taken through a giant telescope and impossible to detect visually. Although M13 far outshines its seemingly tiny companion, M13 is actually completely overwhelmed by it.

Users of large amateur instruments will also find a handful of galaxies roughly two magnitudes dimmer than NGC 6207 centered roughly a degree west-southwest of M13.

In the sky, as on Earth, second best never captures the headlines, as M13's neighbor M92 would attest if it were animate. The former's accolades far outshadow those of its near equal residing 9° northeast. About a magnitude dimmer than M13, M92 nevertheless is worthy of showpiece status. As with M13, naked-eye visibility is difficult, and the succession of instruments described for M13 would bring nearly equal results for M92. M92 is smaller than M13, about 11′ across, but is about equal in surface brightness. Its Herschel designation is IV, which reflects this slightly greater compactness.

Eleven degrees north and 1° east of M13 lies a third globular, NGC 6229. It is small, about 3′ across, but at magnitude 9 it is a fine sight through almost any telescope.

On your next night of observing, M13 will constantly beckon, but don't forget to turn to M92 and NGC 6229 as well. The trio will offer a nicely rounded study of the sky's great globular clusters.

The View from M13

Our perspective far from the center of the Galaxy strongly biases our view of the night sky. Toward the galactic center in Sagittarius the abundance of star clouds and nebulosity invokes an analogy to a dense, diverse city. Elsewhere in the sky are areas disparagingly labeled "voids." The early autumn constellations visible shortly after dark from mid-northern latitudes best exemplify such parcels, so opposite to the richness of the central Milky Way. Not only is the contrast so salient, in terms of human experience, it seems eternal. For all of recorded history, roughly five thousand years, our stars have remained virtually the same. Myth and legend based on their patterns are so firmly entrenched in the world's history, tradition, and culture we hardly think of the sky as a changing entity. Our ancient constellations extend to infinite depths, and as new astronomies reveal exotic, distant objects, hybridized designations, such as Cygnus X-1, partially employing traditional celestial addresses remind us of the apparent timelessness of a unique sky around us.

Imagine now the sky as seen from deep within a globular cluster. We would see multitudes of stars, many as bright or brighter than our naked-eye planets. No obscuring gas or dust would complement or blot out such blazing suns. There are no Milky Ways or Orion Nebulas within a globular cluster. We would see instead a 360° uniformity of stars, a stark contrast to our imbalanced view from Earth. Only from near the fringe of our host globular would we see an uneven distribution. Whereas Earth-bound observers see perhaps five thousand naked-eye stars, an observer deep within M13 or a comparable globular would find several times that number. Assuming that the population is one million stars and that the majority — say 90 percent — lie within a radius of ten parsecs, or 32.6 light-years of the center, reasonable assumptions for a cluster with a 30-parsec diameter, then 900,000 stars would fill our hypothetical 10-parsec sphere. Within this distance many typical globular cluster stars would be within naked-eye limits, and even after allowing for deviations from our assumptions, we would still see abundantly more stars not physically associated with the cluster. A closed system would surround us.

Not only would the globular cluster's sky be richer than ours, its constellations would also be less permanent. The reason is twofold. First, the stars, being closer on the average, would appear to move faster, and second, because of this greater stellar density, greater gravitational interaction would cause them to actually move faster with respect to one another. Although our familiar geocentric patterns would be absent, we naturally could invent constellations in our new setting. Strangely, however, we would continuously need to update our outlines because of the rapid relative motion. Major changes would probably occur every few human generations, while for many millennia here at home they would remain comfortingly constant; despite any and all rapid sociological and technological changes on the surface of our planet, we can always look up and feel right at home in our little corner of the universe. By ironic contrast, the globular clusters, the oldest major stellar communities in the universe, seem so transient from within.

F. Michael Witkoski is an expert deep-sky observer and frequent contributor to Deep Sky. *He has written many articles for ASTRONOMY and is the author of the Planetary Nebula chapter in* Deep Sky Observing with Small Telescopes, *the long-awaited book by the editors of* DSM *to be published this year by Enslow Publishers.*

1987's Supernova in the Large Magellanic Cloud

by Richard Talcott

Astronomers throughout the world have been observing supernova 1987A ever since Canadian astronomer Ian Shelton discovered the anomalously bright star on February 24 in the Large Magellanic Cloud. The behavior astronomers observed during the first few months following the explosion was quite unusual and unexpected, and astronomers at first thought they might be witnessing a unique event. Theoreticians are now convinced, however, that 1987A will shed light on the entire field of supernova research.

Significance of the LMC

As the brightest and nearest supernova visible since Kepler's supernova in 1604, 1987A offers astronomers an unprecedented opportunity to learn more about the mechanisms, dynamics, and aftermath of stellar explosions. And a supernova in the Large Magellanic Cloud is preferable in many ways to one in our own Galaxy.

Lick Observatory astronomer Stan Woosley explains that many supernovae in our Galaxy go undetected because they are obscured by clouds of interstellar dust. In addition, even if a Milky Way supernova did become visible, its distance may be difficult to accurately determine. The LMC supernova is close enough for us to observe in detail, it is not blocked from view by intervening dust, and the distance to the LMC is well known.

Early Spectral Observations

As soon as word of the supernova spread, observatories throughout the Southern Hemisphere mobilized to meet the challenge 1987A presented. Astronomers were primarily interested in getting detailed spectroscopic and photometric observations of the supernova as early in its evolution as possible. Only a handful of supernovae are discovered before they reach peak brightness, so 1987A's discovery less than one day after it began brightening offered observers a rare chance to examine the early history of a supernova outburst. In addition, supernovae evolve most rapidly at the outset, so frequent observations are needed to monitor these early changes.

Early spectral observations of the supernova revealed strong lines caused by hydrogen, which confirmed that 1987A was a Type II supernova. A Type II supernova occurs when a star larger than about eight times the mass of the Sun exhausts its nuclear fuel.

Such a massive star begins its existence as other stars do, converting hydrogen into helium in its core. This conversion occurs at a prodigious rate, however, and within just a few million years the hydrogen in the core runs out. The weight of the overlying gas then raises the central temperature and pressure high enough to start helium fusion reactions. The process of creating heavier elements from lighter ones continues as first carbon, then neon, oxygen and silicon form.

These reactions occur at ever-increasing rates as the core's temperature continues to rise. Helium burning may take half a million years, but silicon is converted into iron in only one day. At this stage the process stops. Because iron is the most stable element, no energy is generated by nuclear reactions in the iron core. Without energy there is no internal source of pressure to support the overlying layers, and the core collapses catastrophically. This implosion stops abruptly when the core is compressed to the density of an atomic nucleus, about 10^{14} times the density of lead, and a shock wave is created that propagates outward. This shock wave literally blows the rest of the star into space, creating the supernova.

These stellar explosions are important because they spew large amounts of heavy elements into space. Most of the elements between helium and iron are formed in massive stars and ejected during supernovae explosions, while all the elements heavier than iron are formed in the last seconds of stellar collapse.

What remains of the original star? Just the compact iron core, which now has the density of an atomic nucleus. This neutron star possesses all the angular momentum present in the original star, and because the neutron star has such a small radius, it rotates very rapidly. The magnetic field of the original star is also greatly strengthened by the collapse, and if the neutron star emits energy along the axes of the magnetic field, it is also known as a pulsar.

Verifying the Core Collapse

An important confirmation of this model of Type II supernovae came not from remote mountaintop observatories but from detectors buried deep underground. These detectors recorded the first signals received from supernova 1987A: a pulse of neutrinos.

Neutrinos are produced in enormous quantities inside the collapsing core of a supernova as electrons and protons are squeezed together. The neutrinos formed in this process carry off most of the energy in the explosion: roughly one hundred times more energy than that released as electromagnetic radiation.

Despite this incredible energy, neutrinos are extremely elusive particles

This composite photo shows both the LMC supernova (as the gray "starburst") and its progenitor. The progenitor image was taken by Victor Blanco in 1969 and the supernova image by Wendy Roberts on February 26 this year, both at Cerro Tololo Interamerican Observatory. Courtesy National Optical Astronomy Observatories.

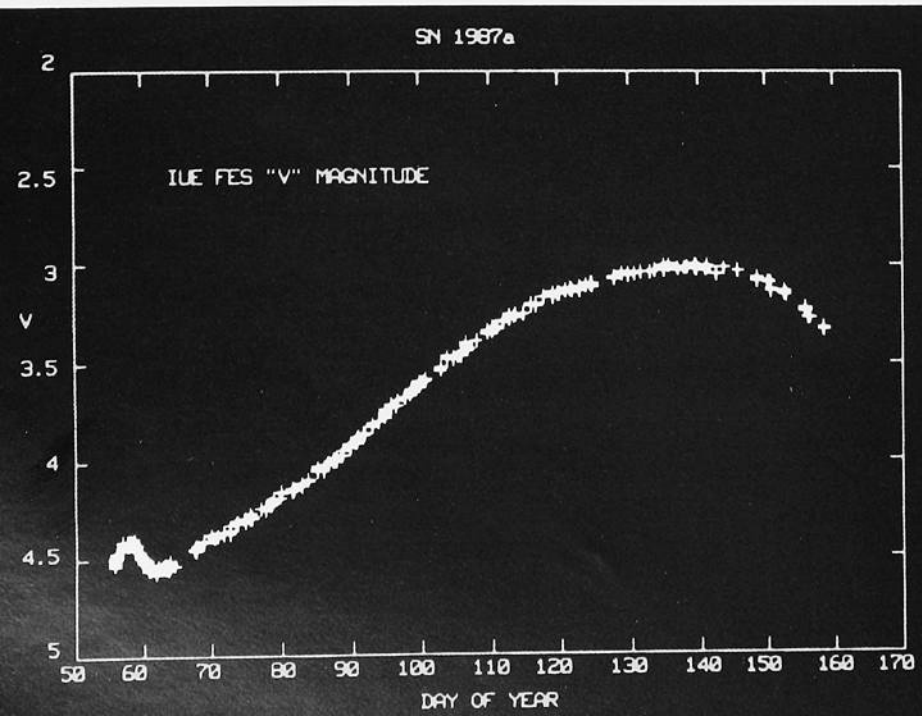
that rarely interact with other matter, which makes them difficult to detect. Physicists have built a few detectors that can do the job, however, even though the detectors were designed for a different purpose. Recent advances in theoretical physics suggest that the proton may be an unstable particle. To test this hypothesis, several groups have built huge underground detectors consisting of many tons of water. If any of the protons in the water molecules decay, the by-products of the event would be recorded by a network of sensors. Although no proton decay has yet been found, the huge detectors do stop an occasional neutrino (out of the trillions that pass through every second).

Approximately three hours before the first light from 1987A reached Earth, bursts of neutrinos were recorded by two independent experiments. The Kamiokande-II experiment, a collaboration of the University of Tokyo, Niigati University, and the University of Pennsylvania, recorded eleven neutrino events over a thirteen-second interval.

At almost exactly the same time a University of California at Irvine, University of Michigan, and Brookhaven National Laboratory experiment located in a Morton Thiokol salt mine near Cleveland, Ohio, detected eight neutrino events in a six-second interval. The near-perfect coincidence convinced astronomers that the neutrinos emanating from the collapsing core had been detected.

Neutrino Implications

As important as the neutrino observations are in understanding the physics of the core collapse, these observations also hold other significance. Perhaps most important is the possibil-



Top: ***Ian Shelton discovered the brightest supernova of the past 383 years in this 3-hour exposure of the LMC, taken February 24.06-24.19 UT with the 10-inch refractor on Las Campanas Mountain in Chile. Courtesy University of Toronto.***

Center: ***Located just 18′ west and 10′ south of the Tarantula Nebula, 1987A rivaled and later surpassed that nebula as the brightest object in the LMC. Joe Cauchi took this 22-minute exposure on March 6 with a 10-inch f/5 reflector on 103a-E film.***

Left: ***Supernova 1987A took an unprecedented three months to reach peak brightness. This chart shows V magnitudes derived from readings taken by the IUE's Fine Error Sensor. The supernova reached peak brightness eighty-five days after it was discovered. Courtesy Robert Kirshner, George Sonneborn, Michael Crenshaw, and George Nassiopoulos.***

ity of measuring the mass of the neutrino.

A debate has raged for years over whether or not the neutrino has a mass. The theory from which neutrinos spring assigns them a zero rest mass, but some more recent experiments indicate neutrinos have a small, nonzero rest mass. The rest mass of the neutrino determines the speed at which it travels: if the mass is zero, the neutrino must travel at the speed of light, while a nonzero mass requires a speed less than that of light. A consequence of this latter view is that neutrinos of different energies will travel at different speeds with higher energy particles traveling faster.

By measuring the arrival times of the neutrino events observed in Japan and the United States and making assumptions concerning the manner in which they were emitted, several theorists have calculated independent values for the neutrino mass, or at least an upper limit to the mass. There is as yet no agreement on this value, though most of the results are in the vicinity of about 10 electron volts or less. Many astronomers feel the data are consistent with a zero rest mass.

In addition to the ramifications a mass for the neutrino would have in physics, neutrinos could decide the fate of the universe. If the universe contains enough mass, gravity will eventually halt the current expansion and reverse it, making ours a "closed" universe. If not, the universe will be "open" and expand forever. Neutrinos are so numerous that even if each one has a mass of just 20 electron volts, the total mass of neutrinos would be enough to close the universe.

The other major implication of the neutrino observations concerns the future of neutrino astronomy. Although experiments observing solar neutrinos have been carried out for nearly twenty years, neutrinos produced by other astrophysical processes have gone unobserved.

Now that neutrinos from beyond the Sun have been observed, astronomers are eager to build large "neutrino telescopes" to observe other events. The prime targets are the Sun, which seems to be emitting substantially fewer neutrinos than predicted, and other supernovae. None of the current detectors is large enough to record neutrinos from supernovae beyond the Magellanic Clouds, and larger detectors would also yield better statistics on the neutrinos from nearby supernovae.

Supernova Photometry

The most perplexing aspect of 1987A's behavior in the months following the explosion was its light output. On the night of its discovery the supernova shone at about magnitude 4.5, which was some eight magnitudes brighter than on the previous night. The supernova varied slightly for a week or so after that and then began to brighten slowly but continuously into May. Peak brightness occurred around May 20 at a visual magnitude of 2.9, and the supernova has been slowly fading ever since.

Certainly 1987A does not fit the classic profile of a Type II supernova. A typical Type II brightens rapidly, reaches a maximum within a couple of days, and then fades slowly. Not only is the profile of 1987A unusual, but so is its absolute brightness. After the initial rise in brightness in late February, the supernova was some thirty times fainter than a typical Type II supernova.

The Color Reddens

Another area in which 1987A is atypical is its color evolution. As most supernovae age, they emit a greater share of their radiation at longer wavelengths. There are two reasons for this reddening effect. First, the extremely high temperature that characterizes the initial explosion gradually cools, and cooler objects give off a greater percentage of their light at longer wavelengths. Second, the velocity of the expanding shell drops as it encounters material in the surrounding area. This slowdown reduces the Doppler blueshift in the supernova's spectrum, effectively making the overall color more red.

In the LMC supernova this general pattern held true, but the rate at which the reddening occurred was greatly accelerated. Shelton and Barry Madore observed the color of 1987A evolve about five times faster than a typical Type II supernovae during the two weeks following the outburst. After that the color of 1987A seemed to stabilize. Such a "plateau phase" is normal for Type II supernovae after peak brightness, but 1987A was getting brighter at the time.

What Preceded 1987A?

The key to understanding the unusual facets of 1987A's behavior is the progenitor — the star that became the supernova. Almost as soon as light from the explosion reached Earth, astronomers began searching for the progenitor. The region surrounding the Tarantula Nebula had been photographed and mapped extensively prior to the outburst, so most astronomers thought the search would be successful.

The major problem facing observers trying to identify the progenitor was the overwhelming brightness of 1987A itself. Because most of the stars in the supernova's immediate vicinity were lost in the glare of the supernova, astronomers could not tell which stars were still shining and which one was not. With such a large potential return, however, astronomers sought an alternate method.

Working with the observed position of the supernova, several astronomers went back to old photographic plates of the area and tried to match positions. Using this method, Robert McNaught of Siding Spring Observatory in Australia identified a potential progenitor — a star catalogued in 1969 by Nicholas Sanduleak of Case Western Reserve University and known as Sanduleak (Sk) −69°202. The star was a hot supergiant of spectral class B3 and had a magnitude of 12. A close examination of earlier photographs revealed that Sk −69°202 has two close companions, one about 2.5 arcseconds away and the other less than one arcsecond distant.

As more observations were made, the errors in the supernova's position were reduced. Within two days European Southern Observatory astronomers in La Silla, Chile, determined the position to within one-quarter of an arcsecond, which allowed them to rule out the more distant companion as the progenitor. They could not be certain which of the other two had exploded, but they were confident that one of them was the progenitor.

Indecision over the progenitor lasted a few weeks, fueled by two quite reasonable doubts. First, most astronomers expected a massive star near the end of its life — the kind of star that becomes a Type II supernova — to be a red supergiant. Since Sk −69°202 was a blue supergiant and there were no nearby red supergiants, many astronomers were uneasy with the apparent contradiction. Second, ultraviolet observations of 1987A taken by the *IUE* satellite less than a week after the explosion revealed the spectrum of a B3 supergiant star, the star presumably destroyed by the supernova explosion.

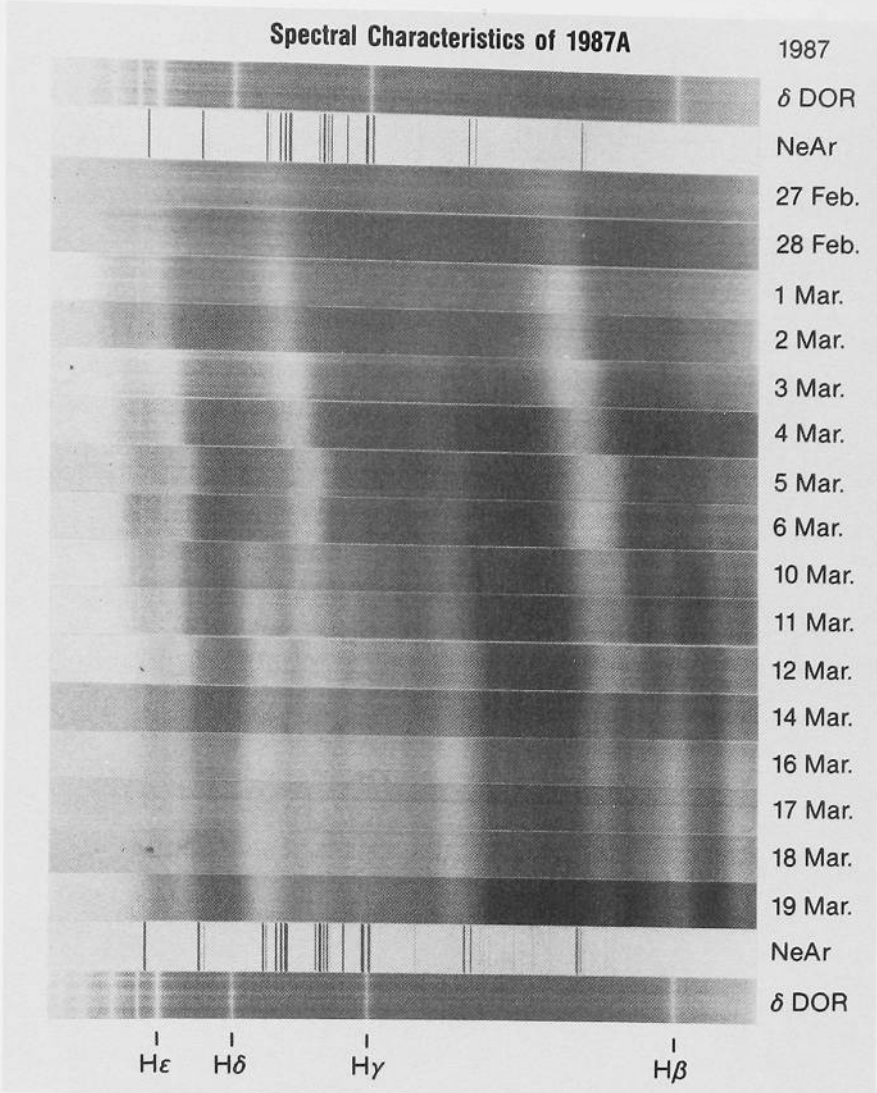
The doubts proved unfounded, however, and subsequent positional measurements, including a definitive study by the same *IUE* group, convinced astronomers that Sk −69°202 was, indeed, the progenitor.

Understanding the Unusual

Supernova 1987A is only the second supernova for which astronomers have been able to identify the progenitor. This knowledge has proven essential in understanding the supernova's unusual nature: Sk −69°202 had the precise properties necessary to generate 1987A's observed behavior.

Sk −69°202 was a blue supergiant —classified as a B3 I star — with a visual magnitude of 12.36 and an absolute magnitude near −8. When the star was on the main sequence, it had a mass about twenty times that of the Sun, give or take 5 solar masses, and was about 10 million years old when it exploded.

Models calculated by Stan Woosley and his colleagues show that at the time of the explosion Sk −69°202 had a helium core of between 5 and 7 solar masses and that the collapsing iron core was between 1.3 and 1.7 solar masses.



Top: *Early spectra of 1987A show the classic signature of a Type II supernova: broad hydrogen absorption lines. These lines are highly blueshifted because of the rapid expansion of the supernova — as high as 18,300 kilometers per second the day of discovery. The expansion slows as the supernova ages, so the absorption lines drift toward longer wavelengths, although they are still blueshifted. A laboratory emission spectrum from a neon-argon source and an absorption spectrum from the A-type star Delta Doradus are included for comparison. Courtesy Robert Garrison, University of Toronto.*

Above: *The entire LMC is visible in this March 2 photo by Vernon Crock. Supernova 1987A and the Tarantula Nebula are nearly equal in brightness and located above and to the left of the LMC's main arm; the supernova is the lower right of the two. Vernon used a 105mm f/2.8 lens and Kodak Tri-X film at 650 ISO to make this 4-minute exposure.*

The neutrino bursts reported in Japan and the United States can be explained by the collapse of an iron core of this size into a neutron star.

1987A was substantially dimmer than a typical Type II simply because of the nature of its progenitor. A blue supergiant is much more compact than a red supergiant, so when a blue supergiant explodes, the expansion cools the star, making it substantially fainter. This cooling is also responsible for the rapid color evolution seen in 1987A.

The reason more blue supergiant progenitors are not seen is a selection effect. Red supergiants give rise to brighter supernovae, so we preferentially see more of them.

The last major question concerns 1987A's long rise to peak brightness: obviously some internal source of energy kept powering the supernova's emission. One possibility is that the supernova explosion created about 0.1 solar mass of radioactive nickel, which subsequently decays to cobalt and finally to iron. The other possibility is that the newly formed neutron star is a powerful x-ray source. It is certainly reasonable to think both mechanisms are at work, but we won't be able to find out until the debris ejected during the explosion thins enough for astronomers to look inside.

What Happens Next?

Now that astronomers feel fairly confident in their understanding of the LMC supernova, they are using their theoretical models to predict what may happen in the future.

Richard McCray of the Joint Institute for Laboratory Astrophysics at the University of Colorado and his collaborators expect the expanding supernova to thin enough by this fall to become transparent to x-rays and gamma rays. The x-rays will first be seen by the Japanese *Ginga* satellite and may peak in brightness early in 1988. Many astronomers are hoping these observations confirm nucleosynthesis calculations, and as such they could be as noteworthy as the neutrino observations.

Perhaps the most exciting finding would be a powerful pulsar at the center of the expanding shell. No pulsar has ever been found within a year or two of its formation. If astronomers discover one lurking inside 1987A, it will be an extraordinary object — probably the second brightest x-ray source in the sky, having a rotation period of only a few milliseconds.

The pace has slowed quite a bit: the supernova no longer changes substantially on an hourly or even on a daily basis. But astronomers keep pushing forward, realizing their odds of ever observing another supernova this bright and this well-placed are slim. After all, would you let the chance of a lifetime pass you by?

A Viewing Guide to E. E. Barnard's Dark Nebulae

by David Higgins

The most recognizable object in the sky during the warm nights of summer is, of course, that long river of stars called the Milky Way. All along this band of milky light lie many different types of objects. Paradoxically, one of the most fascinating types of objects is also one of the most neglected — dark nebulae. These objects are dust clouds free of nearby stars that, rather than emitting or reflecting light, absorb it and block our view of objects that lie beyond. Because dark nebulae are non-luminous patches that are visible only against a brighter border, many amateur

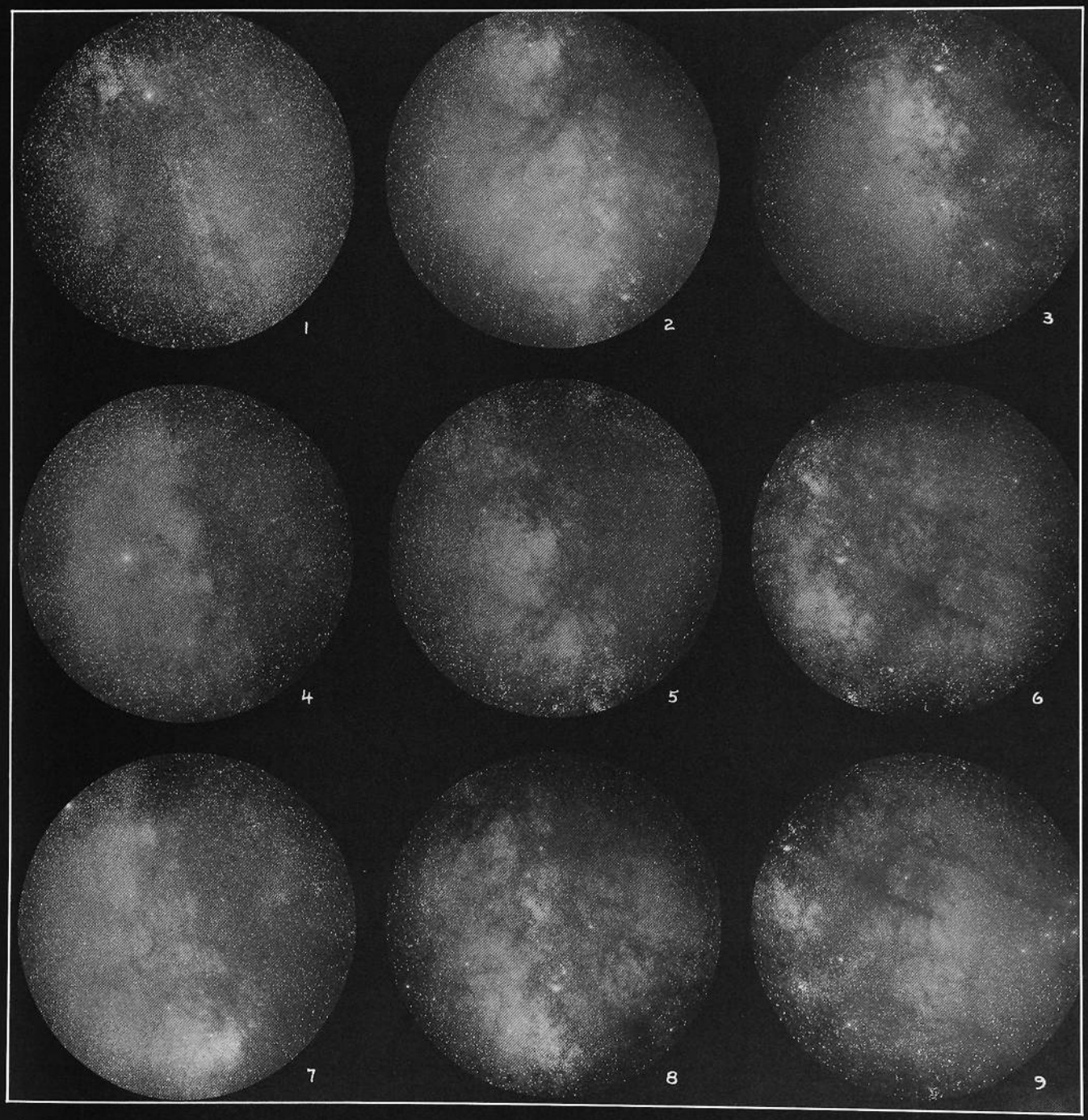
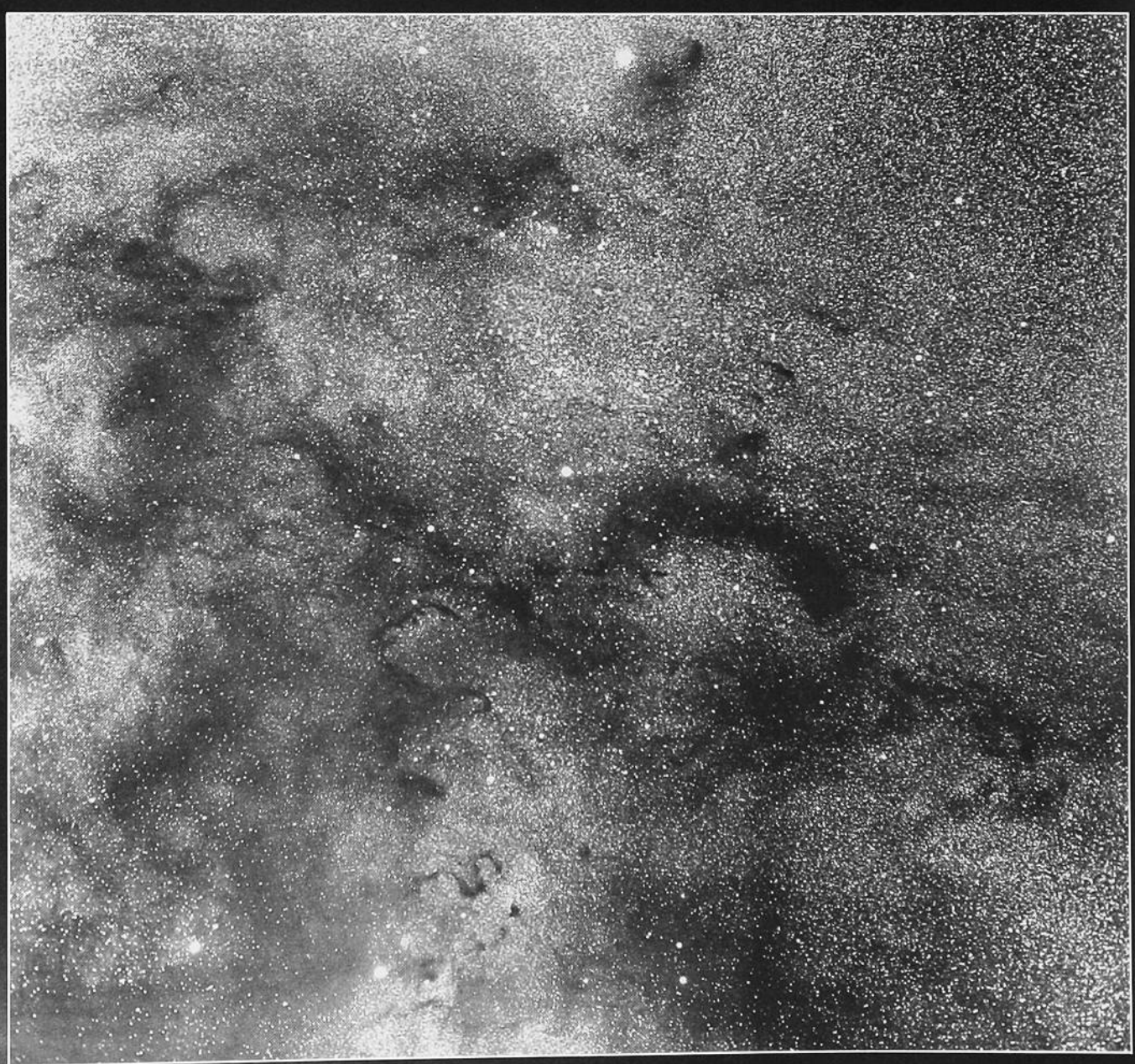


Plate 51 from the legendary **Atlas of Selected Regions of the Milky Way** *by E. E. Barnard shows nine areas of Milky Way nebulosity particularly rich in dark nebulae. Image #1 shows northern Cygnus around Gamma Cygni; #2 depicts the region north of the Lagoon Nebula; #3 shows the area surrounding star clusters M6 and M7 in Scorpius; #4 shows northern Aquila; #5 is centered on the Scutum star cloud; #6 shows the sky west of the Lagoon-Trifid pair and includes the "Galactic Dark Horse"; #7 covers the region between Alpha Aquilae and the Scutum star cloud; #8 is centered on the Sagittarius star cloud; #9 shows a region in Scorpius extending to the Rho Ophiuchi area. These photos were made in 1905 by Barnard, who used a stereopticon lens attached to the Bruce photographic telescope at Mount Wilson Observatory. The 1.6-inch f/4 lens provided sky coverage of 23.2°.*



astronomers don't even consider looking at dark nebulae. Yet observing them offers a challenging, different activity for hot, summer nights when it's just you and your telescope.

Practically all backyard observers are familiar with the great star clouds in Sagittarius, Aquila, and Cygnus. Although these areas contain some of the largest and blackest examples of dark nebulae, most such nebulae are relatively small and difficult to perceive, requiring a large telescope and careful, patient sweeping.

Barnard's Obsession

Telescopic dark nebulae have been observed for over two centuries. In 1784 Sir William Herschel observed what is now identified as the Rho (ρ) Ophiuchi dust cloud. He catalogued many of these objects but couldn't interpret their true nature. Detailed study of these objects had to wait until photography's rapid growth in the late 1800s.

In 1884 Edward Emerson Barnard, a professor of astronomy at the University of Chicago, began a series of long-exposure photographs of the Milky Way. During the following twenty-five years he photographed and studied the Milky Way and gradually came to believe that its many dark lanes were pockets of obscuring dust and gas. In 1930 the matter was finally settled when Robert J. Trumpler studied the angular sizes of star clusters. Trumpler found that although the sizes of open clusters should linearly decrease with the component stars' apparent brightnesses, many dim clusters didn't follow this rule. The extra dimming Trumpler observed was caused by interstellar gas and dust.

Dark Nebula Literature

Observationally, dark nebulae will test your observing skills to the limit. Because they are dark, they are best observed only when surrounded by bright nebulosity or crowded starfields that make the dark object stand out. To make matters worse, good literature on observing dark nebulae is scarce. Professional astronomical journals discussing dark nebulae are difficult to come by (try a college or large city library), and most amateur magazines mention them only in passing. The most descriptive and accessible catalogue for amateurs appears in *Sky Catalogue 2000.0*, Volume 2. The dark nebula section lists 150 objects with epoch 2000 coordinate centers and brief descriptions. Opacity, or relative darkness, is also provided on a scale of 1 to 6, where 1 is the least opaque and 6 the most.

By far the best work for dark nebula hunters is E. E. Barnard's 1927 classic, *A Photographic Atlas of Selected Regions of the Milky Way*. This book consists of two volumes, one containing photographic prints of regions photographed by Barnard, and the other containing descriptions of the objects and charts that correspond to the photos. Because the photographs in this work are actual hand-pasted photographic prints, the book was very expensive to produce, so less than one thousand copies were made. Thus, today it is an exceedingly rare item. Barnard's *Selected Regions* gives sizes, shapes, positions, and descriptions for 370 dark nebulae, and the charts are very easy to use because they show bright stars and NGC objects as guideposts. Although many of the nebulae visible on Barnard's photos are beyond the reach of amateur telescopes, many of these objects can be spotted by diligent backyard astronomers.

Observing Dark Nebulae

Observing dark nebulae takes patience and slow, deliberate sweeping with a wide-field telescope. A large aperture and wide field of view will show the most dark nebulae, but any telscope will show some of them. I use an equatorially mounted 18.5-inch f/4.5 Newtonian with a 32mm eyepiece, which provides a magnification of 63x. However, I sometimes use more magnification for examining small dark nebulae. Although setting circles may be helpful for some observers, I've never used them. Sky darkness is critical regardless of your telescope. Most dark nebulae lie within or on the edge of the Milky Way, so you must be able to see the Milky Way clearly or dark nebulae will be lost.

Summer Dark Nebulae

Object	R.A. (2000)	Dec.	Con	Opacity	Size
B244	17h10.1m	−28°24′	Oph	5	30′ x 20′
B250	17h13.1m	−28°21′	Oph	5	15′
B64	17h17.2m	−18°32′	Oph	5	20′
B70	17h23.5m	−23°58′	Oph	4	4′
B72	17h23.5m	−23°38′	Oph	6	30′ x 3′
B74	17h25.2m	−24°12′	Oph	5	15′ x 10′
B289	17h56.6m	−29°01′	Sgr	5	7′ x 35′
B85	18h02.6m	−23°02′	Sgr	6	—
B86	18h02.7m	−27°50′	Sgr	6	4′
B88	18h03.8m	−24°23′	Sgr	5	2.7′ x .05′
B89	18h03.8m	−24°23′	Sgr	6	2′ x .05′
B87	18h14.3m	−32°30′	Sgr	5	12′
B92	18h15.5m	−18°11′	Sgr	6	12′ x 6′
B93	18h16.9m	−18°04′	Sgr	5	12′ x 2′
B337	19h36.8m	+12°27′	Aql	4	3′
B340	19h49.1m	+01°25′	Aql	5	7′
B142	19h40.7m	+10°57′	Aql	6	40′
B143	19h40.7m	+10°57′	Aql	6	30′
B145	20h03.5m	+86°02′	Cyg	4	35′ x 6′
B356	21h01.9m	+06°31′	Cyg	4	24′
B363	21h26.6m	+08°36′	Cyg	5	40′ x 7′
B169	21h58.9m	+58°45′	Cep	5	60′
B170	21h58.9m	+58°45′	Cep	5	26′ x 4′
B171	21h58.9m	+58°45′	Cep	5	19′

The following describes twenty-four of the best summer dark nebulae, ranging from very easy to moderately difficult. I've tried to give a description of each nebula that will help you identify it when it comes into your telescope's field. I've covered five summer constellations, all of which have bright stars to serve as guideposts in locating these

Opposite top left: ***The large, E-shaped dark nebulae formed by B142 and B143 lies just 2° northwest of Altair. Many other small, winding, dark patches clutter the area, most of which have numbers in Barnard's catalogue.***

Opposite top right: ***The largest and most complex nebulosity in Cepheus is IC 1396, a wreath-shaped hydrogen cloud riddled with dark lanes. In the central part of this nebula are B161, B162, B163, B365, and B367. The bright star Mu Cephei, conspicuously absent in this photo, was at minimum light when the exposure was made.***

Opposite bottom: ***A piece of sky north of Theta Ophiuchi. The most opaque dark nebula in this field is Barnard 63, the broad arc near center. Near top center is B64, a dust cloud just southwest of the globular cluster M9. At bottom center is B72, the "S Nebula," located 1.5° north and slightly east of Theta Ophiuchi. This and the following photos were made in the 1880s and 1890s by E. E. Barnard at Yerkes Observatory. Barnard used the 10-inch f/5 Bruce photographic telescope to assemble the best photographs of dark nebulae for his* Atlas of Selected Regions.**

objects. This list is far from inclusive, but it will get you started in your hunt for some of the best dark nebulae of summer.

Sagittarius

Barnard 85. Most backyard observers have looked at the Trifid Nebula (M20) many times, but few realize that the Trifid's famous dark lanes are catalogued as Barnard 85. These dark nebulae are visible in small telescopes under a dark sky and appear detailed in telescopes of 8 inches or more aperture.

B86. One of my favorite dark nebulae is located in the Sagittarius star cloud, just east of the open star cluster NGC 6520. B86 is nearly square-shaped, measures about 5′ across, and has a high opacity that makes it easy to spot. With low and medium magnifications you'll see both the cluster and nebula in the same field of view, which provides a wonderful contrast of different types of deep-sky objects.

B87. Nicknamed the Parrot's Head Nebula, this large and roughly oval object lies about midway between Gamma (γ) Sagittarii and the brilliant open cluster M7 in Scorpius. B87 measures 12′ in diameter and is surrounded by several other dark nebulae visible in small scopes. Several stars shine through the dark nebulosity, creating an interesting effect. (I must confess that this object really doesn't look like a parrot's head to me.)

B88 and **B89**. Both of these nebulae lie inside a well-observed Messier object, the Lagoon Nebula. With a large telescope B88 is visible along the southern portion of M8 and has an almost wispy appearance. B89 is a narrow dust lane that runs almost completely across the face of M8. It measures roughly 2′ by 0.5′ and is easily visible in even small telescopes. Next time you observe the Lagoon, try using a UHC filter: it brings out the dust lanes extraordinarily and will provide a stunning view.

B92. B92 is another dark nebula involved with a Messier object: it lies directly in front of the brightest part of star cloud M24. The dark cloud measures 15′ by 9′ and contains a single, 12th-magnitude star in its center. B92 is one of the best-defined dark nebulae because it is surrounded by thousands of stars in the dense Sagittarius Milky Way.

B93. Lying about 20′ northeast of B92 is the impressive dark nebula B93. This well-defined object measures 6′ by 2′ across but is connected on its southern end to a long dark nebulosity 15′ long. B93 is very opaque and easily seen, but the southern extension is irregularly shaped and not as easily visible. The northern end of B93 is slightly rounded and more opaque than the southern end, which gives it the appearance of a dark comet.

B289. This large dark nebula lies 2° southwest of B93 and measures a whopping 35′ by 7′ across. It is oriented north-south and requires a wide field and north-south sweeping to spot.

Ophiuchus

B64. This nebula lies only 30′ west of the bright globular cluster M9. The nebula measures 20′ across with an odd-shaped extension oriented north-south. This extension has an opaque northern section and a wide, less well-defined southern section.

B70 and **B74**. Both of these nebulae lie in the same wide field eyepiece. B74 lies about 30′ west of 44 Ophiuchi, measures 15′ by 10′, and is elongated north-south. It is slightly curved and has an extension on the northern side; the western and southern sides are the most opaque. B70 lies about 30′ northwest of B74 and is much smaller, measuring 4′ across.

B72. This is one of Barnard's most famous objects, the spectacular "S Nebula." It measures 30′ across, so you'll need a wide field of view to see the "S" shape. B72 lies 30′ north of B70 and is only 2′ to 3′ wide.

Aquila

B142 and **B143**. Both of these nebulae lie about 1° west of the bright star Gamma (γ) Aquilae and only 3° northwest of Altair. B142 forms an irregular horseshoe shape. B143 has a well-defined western edge and two narrow streamers 30′ long extending to the west. The eastern edge shows no sharp outline. When observing this field of dark nebulosity, you'll need a wide field of view.

B337. This very dark nebulae lies about 2° northwest of B143 and is oval in shape. It measures 3′ in diameter and has very few stars across the face of the nebulae. Although only a few stars associated with B337, there are two fairly bright stars in the middle of the nebulae that are distinctive and will help with identification. B337 also has a narrow extension extending to the northwest.

Cygnus

B145. Found about 1° northeast of 25 Cygni, B145 is a triangle-shaped nebulosity covered by a number of faint stars. It is bordered by two bright foreground stars, one on its northern edge and another on its eastern edge. The eastern edge is more opaque than the rest of the nebula. B145 measures about 45′ long and is oriented east-west.

B356. This large, oval, dark nebula lies about halfway between 59 and 60 Cygni. The nebula's eastern edge is more opaque than other parts. There are some field stars scattered across the nebula; a bright field star is visible on the southeastern edge.

B363. B363 is a complex of gas and dust measuring 40′ across, located just 1° northwest of the scattered open cluster M39. The western end of B363 is larger than the eastern end, but the eastern edge has two extensions easily visible in small scopes. A bright field star lies on the southwestern edge, but very few stars are visible across the nebula.

Cepheus

B169, **B170**, and **B171**. All of these nebulae lie a degree northwest of Zeta Cephei. B169 is shaped like an elliptical ring about a degree wide and encloses a small group of stars. The northern portion is very distinct, though the southern portion less so. B170 is the northwest edge of B169 and is an irregularly shaped strip spanning 26′ by 4′. It is very opaque, showing no stars whatsoever across its surface. B171 lies on the eastern edge of B169 and is an irregular area of nebulosity about 19′ long. This nebula is easily visible in small telescopes, and shows no stars inside its boundary.

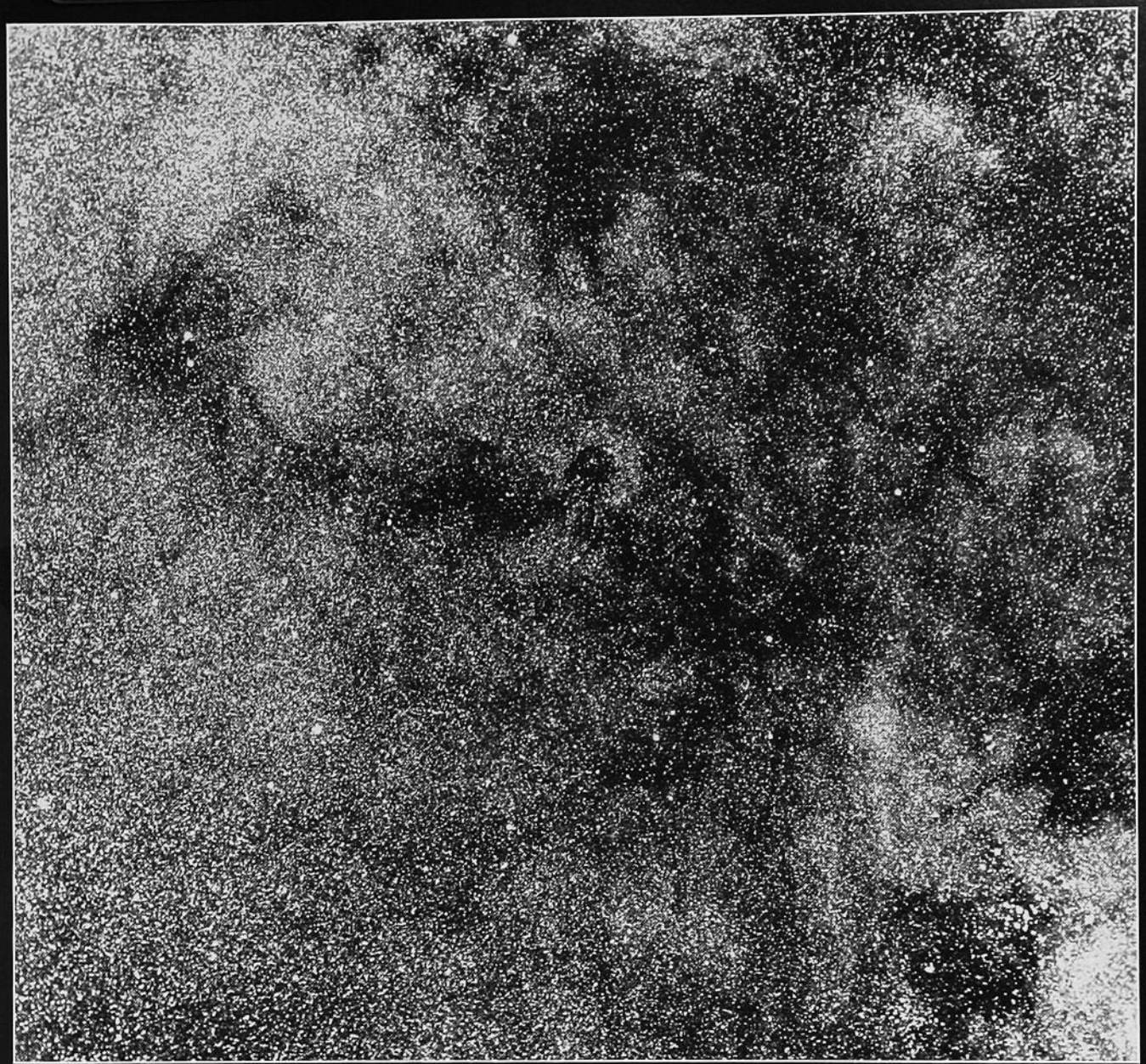
Each dark nebula has its own distinctive characteristics. Some show well-defined boundaries; others merge gradually into surrounding star clouds. Although I have spent many hours tracking down and observing these faint objects, their subtle differences never fail to surprise me. The next time you are out under a dark sky, try viewing one of these cosmic voids. With a little patience and determination you'll be able to see nebulae thought to be photographic objects only a few years ago.

David Higgins is an active observer living in Krebs, Oklahoma. Twice he has served as one of the organizers of the Texas Star Party, and he is one of the creators of the Okie-Tex Star Party. David is also the Central Coordinator of the National Deep Sky Observers Society.

Opposite top: ***Plate 28 in Barnard's* Atlas *shows a region south of the large Sagittarius star cloud. The small, round dark nebula B87 lies at center. This nebula is easy to spot and is nicknamed the "Parrot's Head Nebula." Flanking B87 are the dark nebulae B300 (left) and B292 (right). The large, oval dark object at upper left is B305; B295 lies at top center.***

Opposite bottom left: ***The small star cloud in Sagittarius, also known as M24, is an alluring sight. The two prominent dark patches projected on the cloud are B92, the oval patch on the cloud's northwest side, and B93, the rectangular patch just to its east. Note the solitary 12th-magnitude star centered in B92. M17, the Omega Nebula, lies 2° north of the cloud.***

Opposite bottom right: ***Located in southern Cygnus is the huge, fin-shaped dark nebula B144. Near the center of this cloud of dust grains lies a small bright nebula; the tiny, triangular dark patch B145 lies just north of B144.***



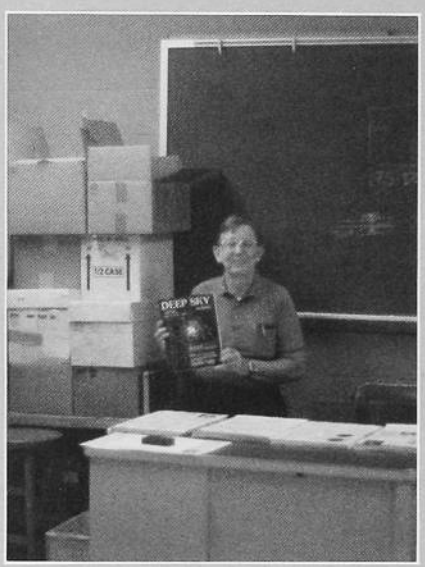
REACHING DSM'S TENTH

Deep Sky's editor peers back at the magazine's history and peeks into the future of deep-sky observing.

One day in 1976 I sat in a Talawanda High School history class, bored. The lecture was on George Washington, and I'd already heard all about George Washington from my father, who is an amateur historian. It was a warm spring day, and my eyes and mind wandered away from the blackboard. I spotted the flashy back cover of a magazine sporting an orange telescope and picked up the magazine to leaf through it. I was entranced by the secret world of numbers and mysterious scientific phrases and ads for doohickies and photographs of the universe. I had always been curious about the sky and stars, but this started my mind reeling. I asked if I could tag along during an observing session with the local astronomy club. When a club member showed me Saturn through a 4-1/4-inch telescope, I was hooked.

After a while, however, planets became rather dull. After all, there were only eight of them. I spent the first few weeks of the summer of '76 stalking clusters, nebulae, and galaxies with an old pair of 7x50 binoculars. These weeks remain the most exciting and adventurous time I have had as an observer, because I had no idea what these mysterious objects would look like. I simply went out into the cornfield in back of our yard and memorized star patterns and saw which objects I could see and marked those I couldn't. This went on all night, whenever it was clear. I had only the binoculars, a dim red light, and a copy of Neale Howard's *Telescope Handbook and Star Atlas* borrowed from Miami University's library in Oxford, Ohio, where I was born and raised.

The humble beginnings of *Deep Sky* form a complex story. I became involved with the Astronomical Association of Oxford, Ohio (AAOO), the local astronomy club at that time. The group produced a newsletter called the *AAOO Observer*, which contained club news, a calendar of celestial events, and two or three columns about observing. As it happened, the person who wrote the AAOO deep-sky observing column had had enough, so there was an opening for his job. I jumped into writing that column and soon deep-sky observing became an obsession.



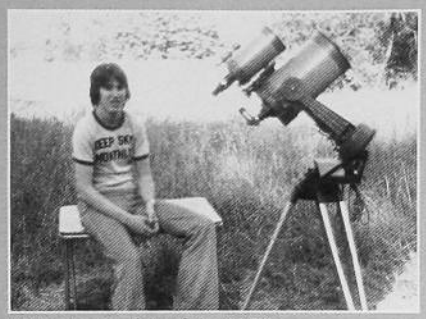
John Eicher in 1981:* Deep Sky Monthly's *publisher, managing editor, financier, and database manager.

At that time my family encouraged me tremendously but probably thought I was a little nuts. After all, I stayed up all night making sketches of stars and galaxies, literally exhausted myself early each clear morning, and came inside the house only to fall asleep in the bathtub where I was trying to warm up. My sister Nancy, now a television news producer in Champaign, Illinois, teased me incessantly about adopting the hours of an astronomer. My mother Susan, who died in 1983, supported me wholeheartedly but perhaps thought I shouldn't be so interested in astronomy that I ruined my health and neglected real life during the day. My father John, a professor of organic chemistry at Miami University in Oxford, was delighted I had become gung-ho about a science.

During the summer of 1976 I contacted Alan Goldstein of Louisville, Kentucky, who had formed a group of observers called the National Deep Sky Observers Society. Alan produces a newsletter called *Betelgeuse*, and I began writing observational reports for it. I continued writing the column for the *AAOO Observer*, became the club's secretary, and soon after its president. On my fifteenth birthday I received a Celestron-8 and began observing even more enthusiastically. Over the months to come I spent hundreds of hours observing with that telescope, making sketches, and comparing various objects with one another. But something underneath it all was gnawing away. I wanted a magazine that contained observing articles, sketches, photos, and a place where deep-sky observers could stay in touch with one another's progress.

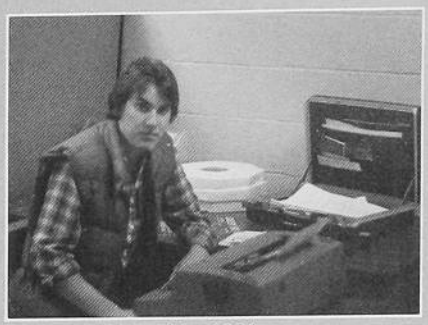
So over the winter of 1976-77 I concocted a plan to start my own magazine exclusively about deep-sky objects. It would contain articles, a calendar listing of bright objects on the meridian at 9 p.m. each night, and feature objects with written descriptions and sketches. I was strongly influenced by ASTRONOMY and *Sky and Telescope*, so I wanted it to come out monthly. What to call it? Well, *Deep Sky Monthly*, of course. The twenty-three members of the Oxford astronomical society were firmly behind me, and at $2.50 per year they all subscribed. The first issue, June 1977, rolled off the mimeograph machine at my dad's Miami office late in May, and I sent the seventy-five or so copies that didn't go to one of the twenty-three subscribers to publications, planetariums, and observatories, hoping to gain some publicity for the new newsletter.

As months passed, issues of *Deep Sky Monthly* gradually became better. Subscribers told me that "every issue is a



With a new friend in 1977

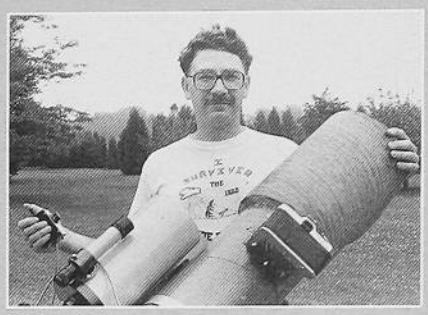
The Eicher house: **DSM** *headquarters*



Eicher at Miami in 1981

1982: The move to AstroMedia

DSM*'s Hamilton, Ohio, press*



Richard Berry

vast improvement!" (Of course, even I knew this was because *DSM* was so amateurish to begin with.) The ten monthly pages became sixteen, and by the magazine's fourth month we began using a crude offset press that reproduced, or at least attempted to reproduce, photographs. We sent the final pages and photos to an NDSOS member who volunteered to print the magazine for us. Three weeks later we received the September issue back. The task must have been awful, because the interested deep-sky observer lost interest in helping with *DSM* immediately. I was stuck with a bit of a problem early in October 1977: I had no place to print the magazine.

There it may have ended were it not for Roger Hoefer, the ever-cheerful and very helpful curator of astronomy at the Dayton Museum of Natural History. (Roger is now director of the Kansas Cosmosphere and Space Center in Hutchinson, Kansas.) Having talked to Roger and others at the Apollo Rendezvous (a meeting of amateur astronomers held at the Dayton Museum), I knew it might be possible to arrange the printing of *DSM* at the Dayton Museum. One night I worked up my courage (thinking that if he wouldn't go for it, the magazine's life would be over) and called Roger. He couldn't have been more receptive or understanding. Thus began a long relationship between my dad and me and Roger Hoefer.

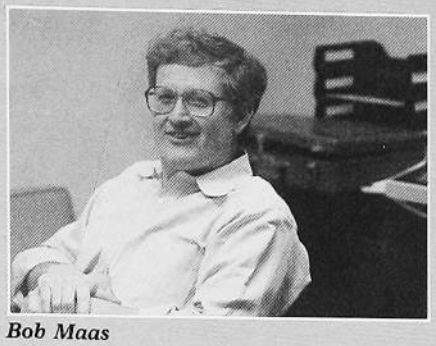
The typical schedule for an issue of *DSM* was to plan and compose it far ahead of time, type the articles onto thick paper sheets with a Miami University chemistry department typewriter, and gather together the photographs and illustrations. Then once a month I drove forty miles to Dayton to make the films and halftones in the museum's darkroom. Roger taught me how to make these films and burn them onto plates for the press. This was usually an all-day process. The next day my dad and I drove to Dayton, this time to use the AB Dick offset tabletop press. Often we arrived to find the press completely clogged with dried and semidried ink and had to clean the machine for a couple of hours before starting to print *DSM*. Occasionally the press didn't work properly, and we had to drive back empty-handed. But when things did go smoothly, we drove up with a folio of pages and photos and came back with several hundred printed magazine sheets.

Although at first *DSM* had a handful of subscribers, publicity in ASTRONOMY and *Sky and Telescope* and word of mouth helped to increase circulation to several hundred. Maintaining the magazine relied on three things. First, my dad financed the project. Second, the Dayton Museum supported *DSM*, allowing us to use its facilities. Third, all of the time put into the magazine — articles, production, managing circulation, and mailing — was donated by the people who worked on it. *DSM* was, by necessity, a volunteer effort, a labor of love.

The AB Dick press at the Dayton Museum could only do so much, and I reached a point in early 1980 when I believed we had to improve the photographic reproduction and switch to glossy paper. So we chose a commercial printer in Hamilton, Ohio, and I continued to make the films in Dayton. My dad made a big lightbox for me and I took the films and taped them into place on sheets that would be burned onto plates in Hamilton. To keep the now relatively high costs at a minimum, my dad insisted on assembling the magazines, one by one, by hand, rather than having them stitched. Every copy of *DSM* — some 50,000 over five years — was handbound by John Eicher.

As *DSM* entered its fourth year, it had accumulated a respectable little following of eight hundred subscribers. But the magazine was still a secret to amateur astronomy, still relatively unknown. (In 1981 Brian Skiff, an astronomer at Lowell Observatory and a frequent contributor, referred to *DSM* as "the underground rag.") Nevertheless, contributions of articles, observations, and photographs began pouring in at a healthy rate. Alan Goldstein, Glenn Chaple, Brian Skiff, David Levy, Mike Witkoski, and others put together some very useful information for backyard observers. Still, trouble lay ahead. My time became more and more limited because I was attending Miami University. The magazine was becoming more and more expensive to produce. The income from eight hundred subscriptions didn't come close to covering the production of *Deep Sky Monthly*. Issues began coming out very late and then several were produced in spurts to try to regain the schedule. Things couldn't continue like this forever.

Early in the summer of 1982 I got a phone call from Richard Berry, editor of ASTRONOMY, an acquaintance from several amateur astronomy conventions, and occasional advisor on *DSM*. Richard asked me to come to Milwaukee to discuss *Deep Sky Monthly*. As it turned out, the May 1982 *DSM*, the sixtieth issue, would be the last. In August I traveled to Milwaukee and agreed to sell the magazine to AstroMedia Corp. and begin work in Sep-



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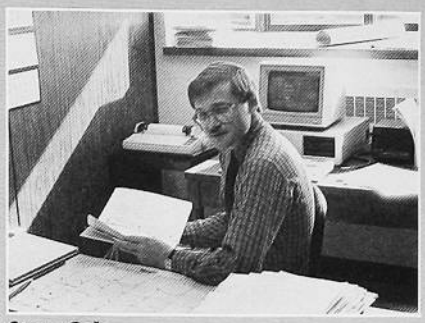
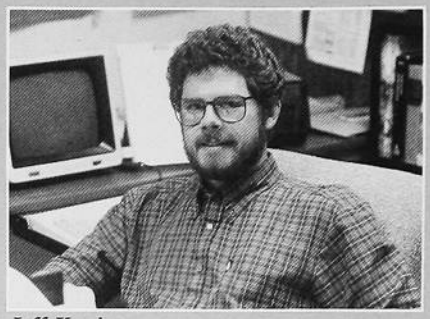


Steve Cole



Jeff Kanipe

Rich Talcott

Kris Majdacic

Todd Graveline

tember as an assistant editor for ASTRONOMY. *DSM* would be published quarterly and retitled *Deep Sky*, and I would continue as editor.

But that was then and this is now. That was five years and nineteen issues ago, and everything that could possibly change about the way *DSM* is produced has. We now have a group of twelve contributing editors, each with expertise in deep-sky observing or photography. We have a young, energetic in-house staff anxious to continue bringing you the best package of deep-sky information on the market. And we have another new owner, Kalmbach Publishing Company. (Kalmbach acquired AstroMedia in 1985.)

So that you know who is who, here's a little information about the people who bring you *Deep Sky*, excised from the Kalmbach newsletter *Proof*:

Richard Berry, 40, is a native of Stamford, Connecticut. He has a bachelor's degree in astronomy from the University of Virginia and a master's degree in astronomy from York University in Toronto. In 1976 Richard joined the ASTRONOMY staff, first as technical editor and then as editor. As well as contributing editor of *DSM*, Richard is now editor-in-chief of ASTRONOMY and the founder and editor of *Telescope Making*. His first book, *Build Your Own Telescope*, precipitated a flurry of telescope building. His second book, *Discover the Stars*, published in July by Crown Publishers, promises to introduce lots of newcomers to the hobby of astronomy. Richard and his wife Eleanor live in Cedar Grove, Wisconsin, where the sky is fairly dark.

A native Milwaukeean, **Bob Maas**, 47, graduated from Marquette University in 1962 with a degree in accounting. He was employed by Arthur Young & Co., a big eight CPA firm until becoming president of AstroMedia in 1977. When Kalmbach purchased AstroMedia Corp. in 1985, Bob became vice president for sales and marketing, and publisher of *Deep Sky*. Bob feels that *DSM* serves a very special purpose for an important group of subscribers. According to Bob, "*Deep Sky*'s circulation is small, but I think it's important to put all our resources behind this magazine just like we do for ASTRONOMY." He and his wife JoAnn live with their two sons, Andrew and Nicholas. He loves to read and travel and claims to have hitchhiked through Europe in 1961.

Steve Cole, 33, moved from Syracuse, New York, in 1985 to become managing editor for ASTRONOMY and *Deep Sky*. He has a bachelor's degree in English from Syracuse University, where he also worked as an assistant director of publications. Steve and his wife Eileen live in Brookfield, Wisconsin, with their sons Sam and Tom.

Originally from Corpus Christi, Texas, **Jeff Kanipe**, 33, is *Deep Sky*'s associate editor and an assistant editor for ASTRONOMY. Jeff received a bachelor's degree in journalism from the University of Texas at Austin and then contributed scripts to the University of Texas radio program "Star Date." He joined the staff in January 1986. Jeff continues to contribute to the McDonald Observatory newsletter, *Star Date* and has a strong interest in astrophotography and galaxies. He summarizes his attitude about observing by saying that "observers aren't limited as much by their equipment as they are by themselves." In addition, Jeff is interested in classical, jazz, and rock music and is a book collector. He specializes in modern American fiction, including Ernest Hemingway, F. Scott Fitzgerald, and John Gardner stories. He lives in Brookfield with his wife Jeanette and daughters Hayley and Carly.

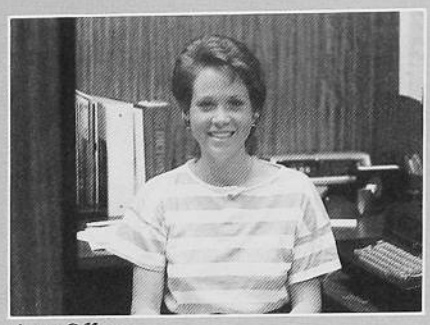
Rich Talcott, 32, was born in Summit, New Jersey, and within a year moved with his family to Stamford, Connecticut, where he grew up. Rich received his bachelor's degree in mathematics from Marietta College in Marietta, Ohio, and then did graduate work at Ohio State University in Columbus. Rich joined the staff in February 1986 and contributes occasional articles when he's not working on ASTRONOMY or enjoying computers and baseball games. Rich and his wife Evelyn live in Milwaukee.

A Sheboygan, Wisconsin, native, **Kris Majdacic**, 28, has been *DSM*'s copy editor since August 1986. Kris has a bachelor's degree in journalism and political science from Marquette University and a master's degree in English from the University of Wisconsin-Madison. Kris lives in Shorewood, Wisconsin.

Todd Graveline, 25, is the art director of *Deep Sky* Magazine. He is responsible for the magazine's graphic appearance and the use of photographs and sketches. Todd is a graduate of the Milwaukee Institute of Art and Design and joined the magazine's staff in June 1986. Todd lives with his wife Jan in Milwaukee. His hobbies are designing neon artwork and collecting old toys.

Tom Hunt

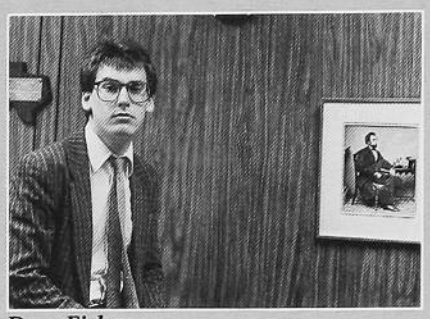
Jennifer Devlin



Amy Offner

Susan Poole

Gary Dolzall



Dave Eicher

Once art director and now an artistic advisor for *DSM*, **Tom Hunt**, 35, is art director of ASTRONOMY. A native of Racine County, Wisconsin, Tom has a degree in visual communication from the University of Wisconsin. Tom lives with his wife Sandy and son Brian near Franksville, Wisconsin. He enjoys painting, drawing, cooking, racquetball, history, and Walt Disney films.

Jennifer Devlin, 23, has been the typesetter for *DSM* since June 1986. She is a native of Chicago and has a bachelor's degree in journalism and mass communication from the University of Iowa. Jennifer and her husband Mark live in Waukesha, Wisconsin.

Amy Offner, 22, has been *Deep Sky*'s editorial assistant since August 1986. A St. Louis native, Amy received a bachelor's degree in journalism from Marquette University. Amy lives in Milwaukee and enjoys running, swimming, and reading.

A Milwaukee native and holder of a philosophy degree from Marquette University, **Susan Poole**, 34, is product manager at Kalmbach. Among her many duties, Susan prepares advertising for and coordinates *DSM* back issue and book sales. Susan lives in Milwaukee, is an avid reader, and enjoys knitting, sewing, and modern dance.

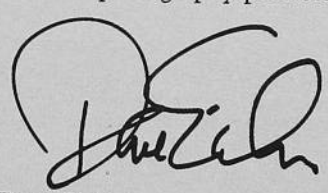
Deep Sky's circulation director is **Gary Dolzall**, 33, a native of Bloomington, Indiana. After receiving a bachelor's degree in journalism from Indiana University, Gary was hired at Kalmbach. He is now in charge of circulation management and marketing and spends a great amount of time operating promotional programs to increase the circulations of the magazines. Gary lives with his wife Donette and kids Paul and Christina in Waukesha.

I'm 25 and interested in lots else besides astronomy. I enjoy playing golf, skiing, swimming, listening to and playing jazz and rock music, and working with my computer. I'm also a bit of a movie buff. My most intense interest other than astronomy is American history. (This is, I believe, a repercussion of having lived in Washington during the summer of 1966.) I've amassed a large library centered on the Civil War, American political history, and general Americana. I enjoy collecting historical letters and documents of astronomers, politicians, and generals, and I very much like traveling to historic spots throughout the country, which I did frequently as a child.

So much for the past. What of the future of *DSM* and deep-sky observing? From talking to amateurs and professionals at meetings and observatories here and there, I can't help but feel excited for the future of backyard astronomy. Ten years ago few observers owned telescopes larger than 12 or 14 inches in aperture. The Dobsonian revolution has changed all that, and now it's common to see 16-inch, 17.5-inch, and 20-inch telescopes at the Texas Star Party, for example. Eyepieces, photo accessories, and telescopes are now better and more easily obtained than they were a decade ago. Now amateurs routinely use hypersensitized film to produce astrophotos that are better than those made by observatories not so long ago. More sophisticated books and atlases will continue to appear during the next few years, giving amateurs the chance to see detail in galaxies and nebulae they had never heard of a few years before.

I think a time will come when the technology of deep-sky observing, by today's amateur astronomy standards, will be shocking. Backyard observers will be equipped with computer-controlled telescopes that will automatically find any area of sky on command. Observers will sit down at a table beside their instruments and watch faint galaxies as they're imaged onto small video monitors fed by CCD chips. Sophisticated nebular filters will become better able to reduce the growing amount of light pollution, filtering out only a galaxy or nebula. Reliable automatic guiders will take the cold out of winter astrophotography as their owners sit inside a warm house and come outside only to start and stop exposures. But where will this leave the art of watching the sky with a simple telescope and star chart? Or making drawings of your favorite galaxies as they appear near the meridian?

I think that no matter how sophisticated the equipment of deep-sky observing becomes, backyard sky watchers will still want the same thing — to view their favorite objects. And I will work hard so that *Deep Sky* continues to improve and provide you with the best coverage of deep-sky observing and astrophotography possible.



Dave Eicher
Editor

Ten Years with *DSM*

by Glenn F. Chaple, Jr.

It's hard to believe a decade has passed since I wrote my first double star column for the then-new publication *Deep Sky Monthly*. And now, some six dozen columns and five hundred double stars later, it's time to pause and reflect on the events of the intervening years.

I first learned about *Deep Sky Monthly* in an ad that appeared in the July 1977 issue of ASTRONOMY Magazine. The ad announced the creation of a newsletter dedicated to deep-sky observing. And the subscription cost $2.50 for an entire year! I couldn't pass up a bargain like that.

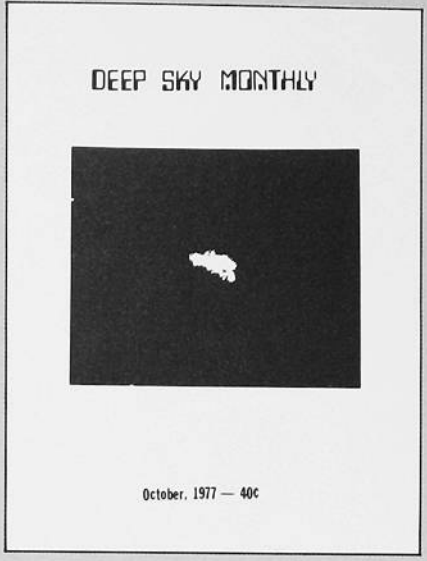
Well, you get what you pay for. The first issue of *DSM* looked as if it had been run off on a mimeo machine, which, of course, it had.

But I saw great potential in this little cottage publication. I also saw a golden opportunity to become an astronomy writer: on the third page of issue #2 was an impassioned plea for articles relating to deep-sky observing. All my life I had wanted to publish something. Here was my big chance.

My first article was the three-part series on double stars that appeared in the October, November, and December 1977 issues. The regular double star column debuted in the November 1977 issue and featured pairs in Aries.

Those first few columns reached a few dozen readers at most. Had someone with less enthusiasm and love for astronomy than Dave Eicher been the editor, *Deep Sky Monthly* probably wouldn't have survived its first year. But within months the magazine was being run off on an offset printing press, operated by Dave. A few years later, *DSM* went "glossy." Meanwhile, Dave was doing all he could to publicize his little magazine through ads in the major astronomy magazines and through appearances at astronomy conventions. He lined up "name" astronomers to pen articles. Slowly but surely, *DSM* grew in quality and numbers of subscribers.

The rest, as the cliche goes, is history. The one-time monthly newsletter is now a quarterly magazine published by Kalmbach Publishing Company with a readership of several thousands. Happy tenth, *Deep Sky*. Congratulations, Dave, on a job well done.



The Earliest Days of *DSM* by Alan Goldstein

This summer marks the tenth anniversary of *Deep Sky Monthly* and *Deep Sky* magazine. Loyal subscribers who have read the magazine since the early days may remember Dave Eicher's wacky adventures getting the magazine out and attending summer conventions to publicize the magazine. Most readers undoubtedly don't know about the heyday of *Deep Sky Monthly*. I know about it as well as anyone, because I frequently traveled to those conventions with Dave and was there to record for posterity what really happened.

I have known Dave since before *DSM* was created (we'll call those days B.D.). In the year 1976, or 1 B.D., a scrappy fifteen-year-old wrote me, an equally scrappy seventeen-year-old, about a group I had formed four months earlier, the National Deep Sky Observer's Society (NDSOS). Dave was editor of the *AAOO Observer*, the voice of the Astronomical Association of Oxford, Ohio, and was writing about — you guessed it — deep-sky observing.

In a letter dated March 3, 1977, Dave wrote, "I am going to start my own publication entitled *Deep Sky Monthly* as soon as I can get some contributing writers. It will be primarily [about] the brightest objects appearing on the meridian at 9:00 E.S.T. in a given month, so it will not conflict with, but will be a good contrast to *Betelgeuse*. I would appreciate you being a staff writer, contributing articles and/or observations." (*Betelgeuse* is the newsletter of the NDSOS.)

I became a staff writer for *DSM*, and the first issue rolled off the press at the end of May 1977. (The press, by the way, was the mimeograph machine at Dave's father's office at Miami University.) The June 1977 issue of *DSM*, volume 1, number 1, was a thin, ten-page listing of deep-sky objects with several brief articles. One of the articles described comets, and a number of people wondered why. (Dave would later claim that the similar appearances of comets and galaxies justified including the article.) The issue reached all twenty-three subscribers, and, although it didn't start with a bang, the era of *DSM* had begun.

I first met Dave in the summer of 1977 in Louisville at the NDSOS' first convention. That was the beginning of a long relationship: over the next five years we traveled over 13,000 miles convention-hopping and establishing our niches in the world of deep-sky observing.

In July 1978 the second NDSOS convention was organized by Dave and his father and held on the campus of Miami University in Oxford. It was a small gathering but a lot of fun (and a lot of work for those involved).

In July 1979 I traveled with Dave and his father to the third NDSOS convention in Topeka, Kansas. We chatted about both *DSM* and the NDSOS for hundreds of miles; there were so many ideas and there was so little help. The very successful convention was managed by Richard Wilds and his friends, and it helped to financially elevate the NDSOS. *Deep Sky Monthly*, however, was still a family-funded project: the now substantial costs of producing it far outstrapped subscription income, and it would enter the new decade with an uncertain future.

In 1980 *DSM* (*a.k.a.* Dave Eicher) made the first of many appearances at Stellafane, along with three fellow intrepid travelers. Picture this scene: In Louisville two high school seniors and fellow Louisville Astronomical Society members, Krishna Myneni and Tim Wells, loaded an old Ford Maverick with gear and hitched a trailer to it. They picked me up, we loaded the trailer with astronomical and camping gear, and — 120 miles later — we picked up Dave. The adventure is best described in my diary.

Day 1 (August 4, 1980): Left Louisville around 5 a.m. Picked up Dave in Oxford, Ohio. Hit heavy fog just north of Cincinnati; it didn't let up until around Colum-

bus. Drove for about fifteen hours to Alden, New York, just east of Buffalo. Spent the night at the residence of Tom Dessert in a tent in his backyard. Tom showed us his observatory, a shed containing a 10-inch Dynascope used primarily for astrophotography. Both his observatory and darkroom were decorated with an impressive variety of astrophotos.

Day 2 (August 5): Left Tom's house around 9 a.m. and headed for Massachusetts. Drove for ten hours. Set up camp at site near Townsend, Massachusetts, near Glenn Chaple's home.

Day 3 (August 6): Did not sleep much: at 3 a.m. this morning a motorcycle gang visited someone in the campsite, producing an ear-splitting roar that lasted half an hour. This morning we stopped at Glenn Chaple's house on the way to Hampton Beach, New Hampshire, where we swam in the cold water of the Atlantic ocean. I forgot to stash my cash — about $200, so I wrapped it in my shirt and buried it in the sand. Stopped at Haystack Observatory outside Boston to look at the maze of radio telescopes and satellite receiving stations. When asking permission from the security guard to enter, Tim used the unfortunate phrase, "Pardon me, I don't know what I am doing." This kept us in stitches for the rest of the day.

Day 4 (August 7): We congratulated Dave on reaching his nineteenth birthday and then Krishna and I slept for about hours. During the day Tim and Dave went to a nearby town to see a rock group impersonate the Beatles. It was at a nightclub, so underage Tim was able to get in only if he didn't go near the bar. He didn't. Later, after a swim in the park's pond, we ate pizza in Townsend. That night we camped in Glenn Chaple's backyard. Observed that night and saw a number of bright meteors. Tim and Dave had been awake for nearly forty-two plus hours.

Day 5 (August 8): Pulled up stakes and followed Glenn to Stellafane. Stopped at Paul Luther's rare book shop. Tim and I bought a large number of old astronomical journals. (Later, I found out that they belonged to the late Harlow Shapley.) We added another one hundred pounds to the trailer. Arrived at Breezy Hill midday. It was our first chance to socialize with people we had only read about in magazines or corresponded with. Listened to some of the tent talks. I vividly remember Ben Mayer's presentation on the Problicom system. It was cloudy and drizzled lightly after dark.

Day 6 (August 9): It is amazing how easy it is to fill an eight-man tent with only five people! We walked around, chatted, and poked around the flea market. Dave and I took pictures for his Stellafane review in Telescope Making. *I met with NDSOS members and listened to the tent talks throughout the day. The evening talks were interrupted with "oohs!" and "aahs!" and applause when bright meteors swept across the sky. Afterward, observing was hampered by high clouds.*

Day 7 (August 10): Last day of Stellafane. Went to town with others for a traditional "end-of-Stellafane breakfast" at the Idlenot restaurant. Then left and went to Dr. Don Greeley's house; on the way we lost one of Dave's suitcases and Krishna's sleeping bag because we thought the trailer was secured. We went sailing on the Greeley's 29' sloop in Hingham Bay and spent the evening on the town.

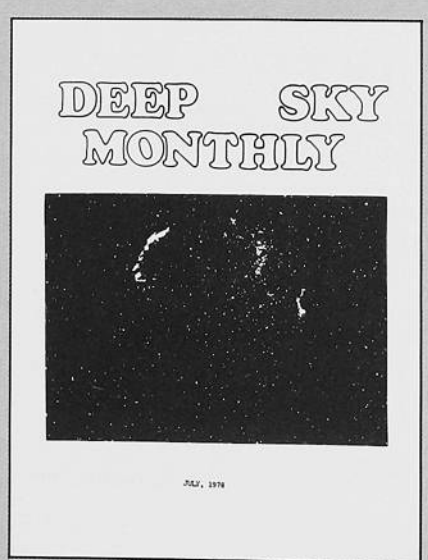
Day 8 (August 11): Went to Boston to see a science museum but got lost downtown because of Beantown's maze of one-way streets. We finally gave up on the museum and went to Harvard College Observatory. We then visited the offices of Sky and Telescope *and talked with Norm Sperling and Dennis di Cicco.*

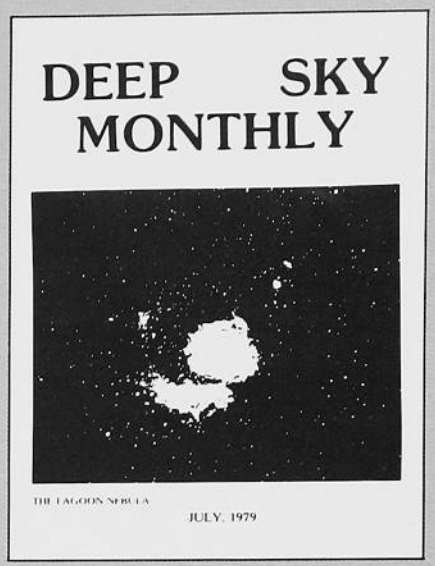
Day 9 (August 12): Left Hingham and finally bought a tarp to cover the trailer. Visited Walter Scott Houston at his home in East Haddam, Connecticut. He showed us his impressive collection of old books and atlases as well as his meteorite collection. That evening we found ourselves at Kettletown State Park near Seymour, Connecticut. While falling asleep we looked for Perseids through the sporadic fog. I zonked out in ten minutes; Dave stayed awake longer and the next morning reported some bright meteors.

Day 10 (August 13): Went swimming at the park, then drove back to Seymour to visit an NDSOS member. Drove from there to Titusville, New Jersey, where we camped at Washington Crossing State Park.

Day 11 (August 14): Moved to a nearby camp area, Bull Island, on the Delaware River. Went to New Hope, Pennsylvania, to eat lunch. We were surprised to find it is a tourist mecca. It dawned on us, just as we were getting ready to leave town, that Questar was based here, so we dropped by to visit. Later that day we swam the rapids on the Delaware River.

Day 12 (August 15): Went to the NDSOS convention held by the Delaware Valley Amateur Astronomers on the Temple University campus in Ambler, Pennsylvania. Dave set up a DSM *display. We talked with attendees.*





Day 13 (August 16): Went on a bus tour to Sproul Observatory at Swarthmore College, where we were greeted by Sarah Lee Lippincott. Then we proceeded to Edmund Scientific Co.

Day 14 (August 17): This was the last big day of the trip. Drove for about fifteen hours back to Oxford, Ohio. It was not an uneventful trip. A trailer tire went flat near Camp Hill, Pennsylvania. We used a thick plank of wood and the car's spare tire as a lever to lift the trailer high enough for Dave to change the tire. Arrived in Oxford at 4 a.m.

Day 15 (August 18): A brief drive home, uneventful except when we nearly got struck by lightning while covering the trailer during a thunderstorm.

In 1981 Dave and I traveled to the Western Amateur Astronomers/National Deep Sky Observer's Society convention in Orange, California. It certainly was an adventure: Dave's Datsun 210 hatchback had three weeks' worth of gear packed inside and a luggage rack on top. It must have looked ridiculous. Despite Dave's penchant for fast speeds ("if we don't keep movin', we'll never get there!"), we still got about twenty miles per gallon. Even more surprisingly, we had no car trouble. We ran out of interesting, cheerful conversation the first day. During the next twenty days, as the trip became more and more exhausting, the communication deteriorated into a series of sporadic discussions and debates.

Day 1 (July 15): Dave and I traveled to Columbia, Missouri. That night we camped and found our waterproof tent wasn't actually waterproof!

Day 2 (July 16): We drove to Topeka, Kansas, to pick up Norm Butler and his 6-inch Cassegrain binoculars. A special trailer hitch had to be welded together while we waited, and the finished assembly looked like a small antiaircraft gun. Norm

affixed a sign to the trailer reading, "Have Telescope, Will Travel."

First we went south to Wichita, driving between two ominous thunderstorms. We ate a late dinner and the three of us watched a partial lunar eclipse through a restaurant window. We then camped at Lake Afton, west of Wichita, about a mile from a nice little public observatory.

Day 3 (July 17): Traveled 450 miles to Tucumcari, New Mexico. That night we observed a few bright objects before the Moon got in the way. After the Moon rose, we made a general nuisance of ourselves by creating a "light cannon" with an electronic flash and Dave's C-8, spraying blasts of photons all over the countryside.

Day 4 (July 18): Thus began a long day. Drove through Albuquerque and on toward Socorro. We decided to visit the Very Large Array radio telescope, even though we had planned to spend the night in Tucson. The VLA was fascinating: the Plains of San Augustin were in bloom, and the individual radio dishes were large and impressive when viewed up close. Norm and Dave found that their suntan lotion attracted a great cloud of bees, and they had to make a mad dash for the car. Each was stung five times. At sunset we had dinner in Springerville, Arizona, and had only 333 miles to go.

Day 5 (July 19): Still on our way to Tucson. We passed through the Salt River Canyon after midnight. We would not have made it up the first hill had we gone during the day, because the car was loaded and we were pulling a heavy trailer. After being tired and mesmerized by the view of the canyon for twenty or thirty minutes, we noticed suddenly that the gas gauge was near "E," an uncomfortable discovery since we were 235 miles from the nearest town. Almost unbelievably, we made it to Globe, Arizona, on fumes, refueled, and pitched our tent in Tucson at 4 a.m.

I awoke perhaps four hours later. The Sun was beating down on the tent, which was still damp from rain several nights earlier. The air inside was nothing less than stifling. Even Dave, who normally requires a small armed conflict or marching band nearby to awaken, was up a few minutes later.

Later that morning Dave and I visited Kitt Peak National Observatory. We walked around looking in visitor's galleries, reading the signs and noticing that there are a lot of lizards at 7,000 feet! At 5 p.m. we left Tucson and headed for California. We decided to drive through the desert at night. At a Phoenix rest stop at 10 p.m., the mercury read 106° F.

Day 6 (July 20): At 7:30 a.m. we pulled into Encinitas, California, and spent the day with the Bauers, friends of Norm's. Late in the day Dave and I drove to north Los Angeles to stay with Ben Mayer. He showed us his video blink comparator (Viblicom) and did some design work for DSM.

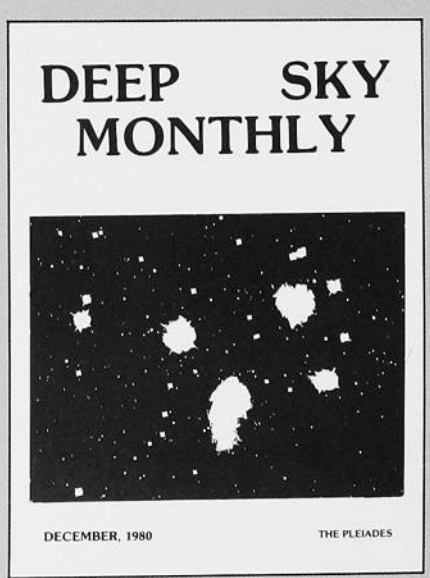
Day 7 (July 21): Dave and I went to Universal City and saw the Universal Studios tour. It took us half an hour to locate the car afterward. Later on Ben took us to the Polaris Observatory site in Lockwood Valley. We looked at M13 and NGC 6946 using his C-14 and an image intensifier.

Day 8 (July 22): We bid farewell to the Mayers and went to Griffith Observatory. Dave and I met with Dr. Ed Krupp and Paul Roques. From Griffith Park we went to Celestron's factory and got a tour from our friend Kevin Ritschel. During the convention, which started today, we stayed with John Sanford and his family in Orange.

Day 9 (July 23): Drove back to Encinitas to pick up Norm and his telescope. Then we set up DSM *and NDSOS exhibits at Chapman College in Orange and stayed there talking to other amateur astronomers.*

Day 10 (July 24): Circulated between our exhibits and the paper sessions.

Day 11 (July 25): The final papers were presented in the morning. In the afternoon Dave and I drove up to Mount Wilson Observatory where a field trip was scheduled. We missed the tours of the solar observatories but did get to see the 60-inch and 100-inch telescopes. Evening activities had us viewing with the 60-inch scope using a video camera and an image intensifier. We observed M19, M57, Neptune, and Uranus. The computer refused to locate M13. A special occulting bar was used on the planets, so we could see Triton and four satellites of Uranus.



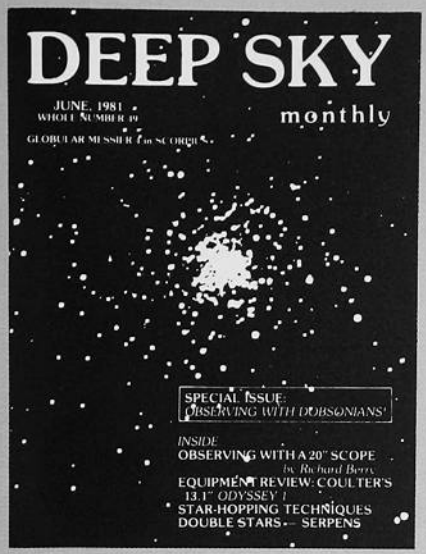
Day 12 (July 26): Dave and I wanted to leave Mount Wilson at midnight but found ourselves locked in! While we waited for the party to leave, we observed from the parking lot with telescopes brought by other amateurs. We drove the Angeles Crest Highway half-asleep and arrived at my friend Bob Ferris' home near Littlerock at 3 a.m. From sunrise to sunset on this day, very little happened. After sunset we observed with Bob's telescopes. His 8-inch f/16 Cassegrain proved excellent for observing planetary nebulae!

Day 13 (July 27): We went to the offices of Mount Wilson and Las Campanas Observatories in Pasadena and then drove to Meade Instruments Corporation and talked with John Diebel. After getting the tour, we drove to Palomar Mountain to visit Al Lilge. His 12-inch f/8 Pro-Scope showed us four components of Stephan's Quintet rather easily. We observed dozens of other objects using this fine telescope.

Day 14 (July 28): Al Lilge gave us a tour of Palomar Mountain Observatory, showing us the 48-inch Schmidt camera, the 200-inch telescope, and the 60-inch telescope. After the tour of Palomar Mountain Dave and I went back to Encinitas to spend some time at the beach. A visit to California without a dip in the Pacific would have been unforgivable. Dave spent some time crashing into the surf, but the water was too cold for anything more than a token splash. That evening we went back to Palomar Mountain to observe many objects with Dave's C-8.

Day 15 (July 29): Drove to Idyllwild, stopping at Coulter Optical Company where we talked with Jim Jacobsen and looked over the prototype Odyssey II 17.5-inch scope. We crossed the Mojave Desert at 1 p.m., passing only six cars in fifty miles. Dave's car did not have an air conditioner, which is just as well, because it probably would have overheated. The route lead us past Bristol Dry Lake and the Amboy Crater, a recent volcanic cinder cone and lava bed. After passing through Kingman, Arizona, we encountered some thunderstorms and rainbows. In Flagstaff we stayed with DSM *writer Brian Skiff.*

Day 16 (July 30): Brian gave us a tour of Lowell Observatory (where he is now employed) and the U.S. Naval Observatory. Brian's friend Chris Luginbuhl showed us how the Navy's famous 61-inch astrometric telescope works. We stood on the catwalk and, as the dome turned, we watched the countryside go by. Brian showed us the 40-inch Ritchey-Chretien telescope (the first of its kind), and of course the 24-inch refractor used by Lowell for his Martian canal observations.



The tour continued to Oak Creek Canyon, the Anderson Mesa observatory site (where Brian showed us the 13-inch 'Pluto camera') and the U.S. Geological Survey image-processing facility, where Brian worked at that time. He showed us the current projects at USGS, his projects, and the library, where every planetary image ever returned to Earth is stored in shelf after shelf of photographic albums!

Day 17 (July 31): Today Dave, Brian, Chris, and Chris' girlfriend Carol climbed Kendrick Peak, an extinct volcano 10,418 feet high. I carried a knapsack full of stuff up the 5-1/2-mile-long trail. As we reached the top, a thunderstorm broke out, pelting us with rain and a sheet of rice-size hail. The five of us ran helter-skelter to the fire-tower on the summit and huddled inside. The trip took us four hours on the way up and only two hours on the way down.

Day 18 (August 1): Drove from Flagstaff to the south rim of the Grand Canyon. We took a few pictures there and as we drove through the Painted Desert. We traveled to Ouray, Colorado, a small, ex-mining town tucked in a valley in the rugged San Juan Mountains. There we met Alexander Brownlee and his wife and stayed with them for a couple of days. We poured over Alexander's many albums crammed with beautiful galaxy photographs.

Day 19 (August 2): After Alexander showed us his book and journal collection, he took us up into the mountains beyond the Camp Bird mine to visit some old gold and silver adits and shafts. We collected mineral specimens but little gold and silver. We had lunch by an old mine at an 11,000 foot elevation. The road up had to be about the worst I had ever been on, which continually rattled his four-wheel drive Jeep.

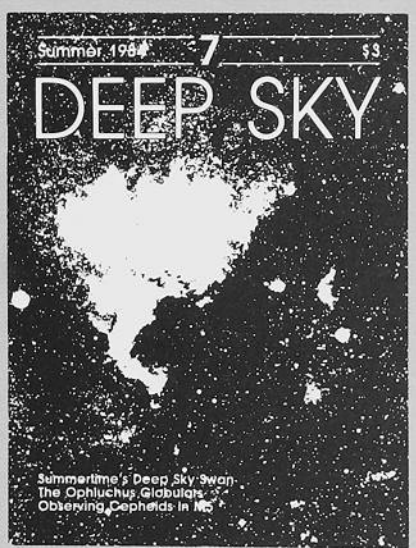
Day 20 (August 3): Heading home! We wove our way through the Rockies, soaking up the scenery along the way. Once we passed Colorado Springs, the land flattened out, the countryside became monotonous, and the average speed picked up. Dave decided to make it home in two days instead of three. We traveled 815 miles to Topeka, Kansas.

Day 21 (August 4): I got home at 8 p.m.; it was nice being back in the muggy Ohio Valley air. For me it had been a 6,004-mile trip and for Dave, 6,274.

My last big trip with Dave was to the 1982 Texas Star Party. This was about three months before the purchase of *DSM* by AstroMedia and Dave's move to Milwaukee.

Day 1 (May 23): Dave pulled into the driveway at 7 a.m., exactly the time he said he would come. After traveling for twelve hours, we camped in Village Creek State Park, near Forrest City, Arkansas.

Day 2 (May 24): On to Texas, but not before having a flat tire an hour's drive from Forrest City. We put on the spare and then bought another tire in North Little Rock. We ended the day (or so we thought) at a KOA campground about thirty miles east of Dallas. Just before dark we stirred up the other campers by spotting a funnel cloud in a thunderstorm that had just passed over. It was moving away from us and never did touch the ground. At about 10 p.m. a heavy thunderstorm moved in. We were in a tent and were not particularly tired, so we decided to pack up and move out with a dry tent.



Day 3 (May 25): We drove through the storm, almost blinded by water. It rained so hard that at times we couldn't see ten feet ahead, so eventually we pulled onto the shoulder and sat until the rain died down. I shined a flashlight outside and found a sign informing us that the town of "Fate" was one mile ahead. All those episodes of "The Twilight Zone" came streaming back to haunt us.

We continued for more than two hundred miles that night and stayed awake by listening to the Larry King Show on the radio. We pitched the tent at 4:30 a.m. and slept until 11 a.m. The campground was on the outskirts of Abilene, Texas. We pulled in to the Prude Ranch around dinnertime and after dark observed many objects, including Omega Centauri, NGC 5128, M57 (and central star), several interacting galaxies, and M83.

Day 4 (May 26): We socialized with friends, missing most of the papers presented that day and observed until the wee hours.

Day 5 (May 27): Dave and I went with other groups on a tour of McDonald Observatory. The summit of Mount Locke was very windy. When we returned to the TSP, Dave and I gave a presentation on deep-sky observing and our experiences, a backdrop of deep-sky slides from Marty Germano serving as illustration.

Day 6 (May 28): Today we listened to many deep-sky related talks. The seminar on the space telescope with Bart Bok, Karl Henize, and Harlan Smith was lively! That evening the wind had died down somewhat, and homemade telescopes were optically tested using a screen on a hill 1/4 mile away. We observed more deep-sky objects, including all five members of Stephan's Quintet.

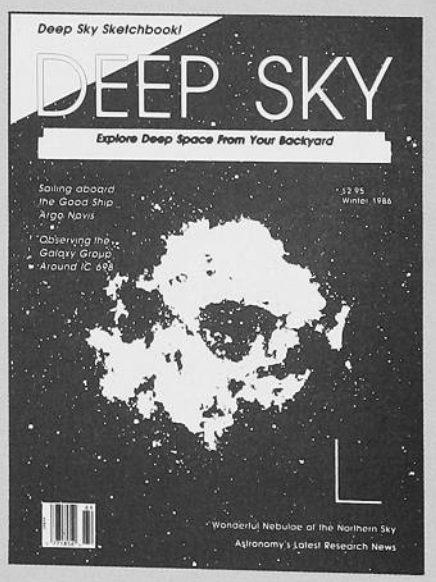
Day 7 (May 29): By now Dave and I were going into no-swim shock, because the pool at the Prude Ranch was out of service. The folks at the ranch provided a bus, so many of the TSP attendees including us went to swim in a stream-fed lake at Balmorrhea State Park. After returning we talked with Clyde Tombaugh and then ate at the Davis Mountains State Park. That evening we listened to Clyde Tombaugh talk about the discovery of Pluto. Bart Bok spoke on the modern view of the Milky Way.

Day 8 (May 30): Left the Prude Ranch after talking with George Ellis and Bart Bok. Drove to Weatherford, Texas (near Fort Worth), and stayed at a KOA.

Day 9 (May 31): Went as far as West Memphis, Arkansas.

Day 10 (June 1): Drove home today.

These are but a few of the adventures Dave and I had while trying to promote *DSM* and the NDSOS. I am sure Dave and other writers and editors can think of many more.


Deep Sky Sketchbook!
DEEP SKY
Explore Deep Space From Your Backyard
Sailing aboard the Good Ship Argo Navis
Observing the Galaxy Group Around IC 698
$2.95
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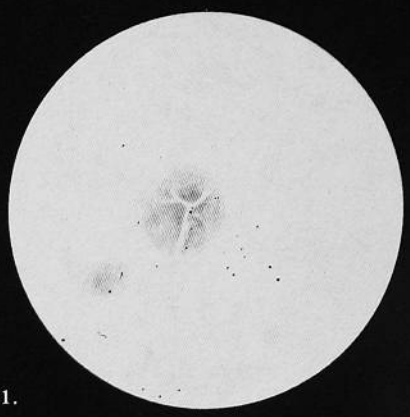
Wonderful Nebulae of the Northern Sky
Astronomy's Latest Research News

DEEP SKY SKETCHBOOK



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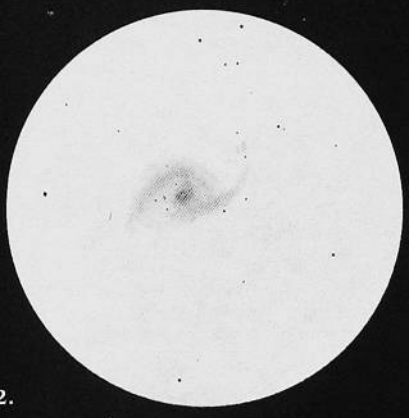

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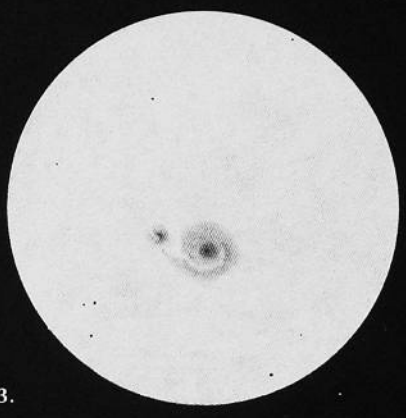

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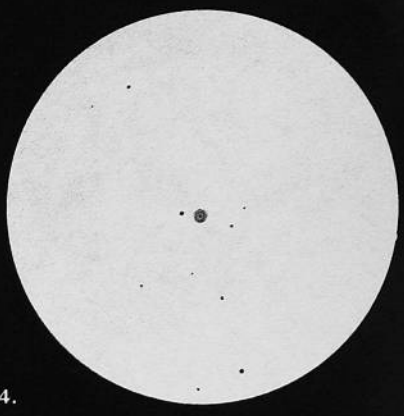

4.

This issue's sketchbook features eyepiece renderings by Michael Sweetman of Tucson, Arizona, who uses a 6-inch f/5 reflector, an assortment of pencils, an eraser, and a Rapidograph 00 technical pen for stars. Sweetman says: "I do drawings every time I go to the telescope and have found that drawing greatly increases one's ability to pick out details."

1. M20, the Trifid Nebula, Sagittarius. 76x with UHC filter. Notes: "Found easily using 6x30 finder. At 64x, M20 is faint but easy to see. Dark lanes and nebular detail are easy with averted vision. With 76x and UHC filter lanes are darker and easily observed. One bright and one faint star lie near the nebula's center."

2. M33, galaxy, Triangulum. 64x. Notes: "Not easy to find but once in field easy to see. Takes magnification well. At 38x some spiral structure is visible. Galaxy's core is bright with mottling and a few point sources of light. Five other starlike features observed near spiral arm. Saw star cloud NGC 604 as a disconnected patch of light off one spiral arm."

3. M51, the Whirlpool Galaxy in Canes Venatici. 73x. Notes: "Found easily at 38x. Large, circular with bright starlike center. Dark lanes and spiral structure visible at 73x. Bridge of material almost connects M51 with NGC 5195, although even with averted vision I'm not sure."

4. NGC 2392, the Eskimo Nebula in Gemini. 64x. Notes: "Rather easy to find at 64x. Lies next to bright star. NGC 2392 has a starlike core with a bright outer ring. Bluish cast noted."

5. NGC 2395, open cluster in Gemini. 73x. Notes: "Faint but noticeable. Peanut-shaped with many faint stars."

6. NGC 4102, galaxy in Ursa Major. 95x. Notes: "Easily picked up at 38x. At higher power appears elongated east-west, about 3′ by 2′ across, and moderately bright. With averted vision outer areas are uneven in brightness."

7. NGC 5557, galaxy in Bootes. 64x. Notes: "Found at 29x. At 64x appears to have a bright, starlike core with a faint outer envelope of nebulosity. Bright star is located nearby."

8. NGC 6624, globular cluster in Sagittarius. 95x. Notes: "Found easily at 38x. At 95x globular is small and bright with a high surface brightness core fading rapidly into a faint outer envelope. Circular with no hint of mottling or resolution."

9. NGC 6528, globular cluster in Sagittarius. 190x. Notes: "Lies in same low-power field as NGC 6522. At 64x has a compact and bright core. At 190x one outer star is visible. Averted vision shows some mottling around the core."

10. NGC 6802, open cluster in Vulpecula. 95x. Notes: "Hard to see at 38x. At 95x still faint and hard to make out any shape. Irregular in brightness with some stars (?). Some mottling observed away from the center. Elongated in a north-south direction."

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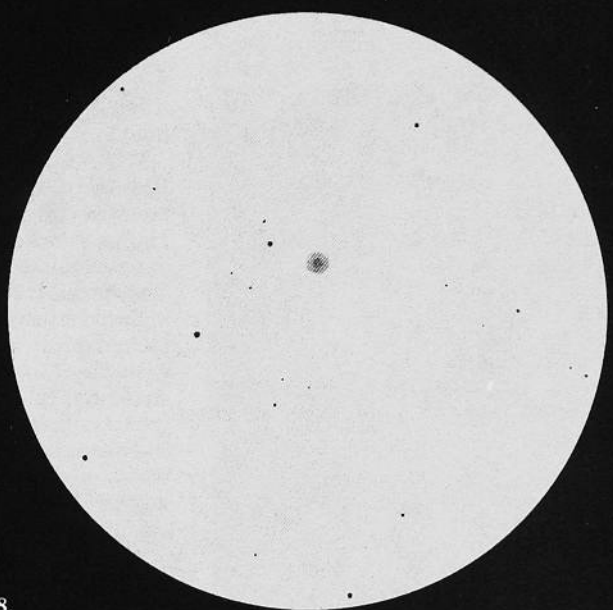

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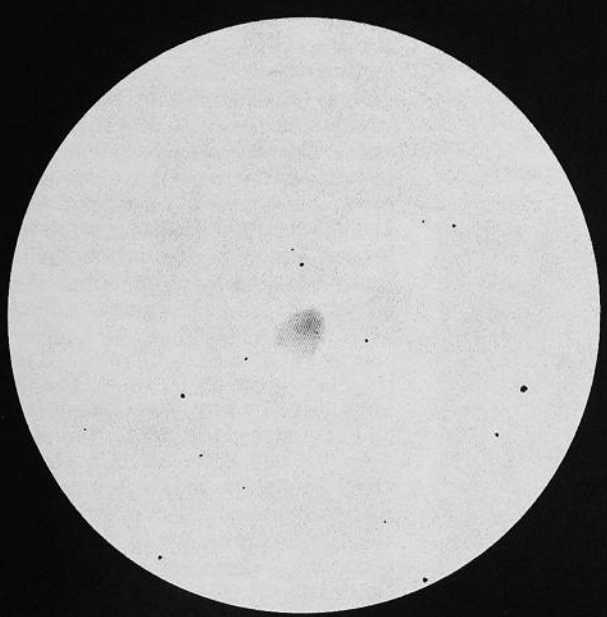

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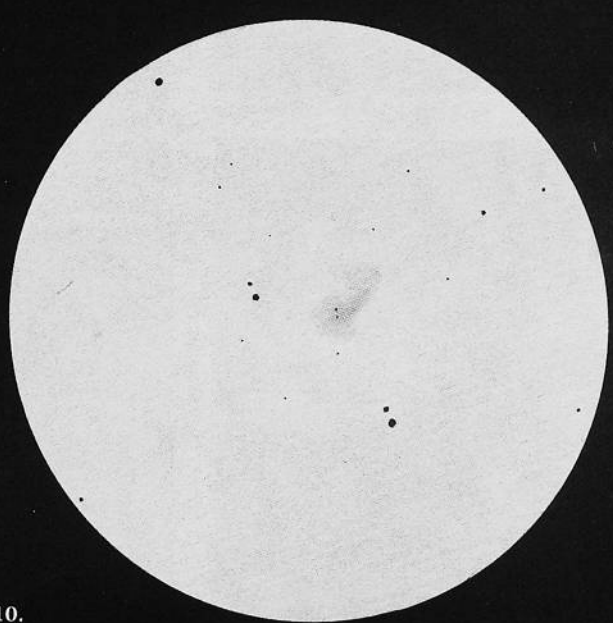


10.

Small Scope Showcase

Summer along the Milky Way

by David H. Levy

During one childhood observing session I separated the main parts of that fine double star Epsilon (ε) Lyrae, just east of Vega. I did it with the unaided eye, right in my own backyard. It was great fun. It seemed then (and still does) to be a real achievement.

At the time I felt I had strained my eyes to pluck one of the sky's secrets. But I got things a little backward — it wasn't so much that I was pulling away secrets, but that the sky itself offers those secrets to anyone who watches and waits long enough.

In summer it's delightful to go outside on a warm night and see Cygnus the Swan, a delicate strand of stars rising high in the northeast sky. This star-studded group is set on a backdrop of the Milky Way. First-magnitude Alpha (α) Cygni, called Deneb, is at one end, while Beta, called Albireo, lies at the other.

With a telescope Beta Cygni shows two stars, yellow and blue, sparkling in a rich field of faint stars right in the middle of the Milky Way. How can anyone look at this field and not feel something? Many observers think Albireo is the sky's best showpiece double star.

The two components are known as Beta Cygni A and B. A is the primary member of the system, while B is known as the *comes*, which is Latin for "companion." Albireo is a binary system, and B orbits around A. One night some people were looking through the old 6-inch refractor at the Observatory of the Montreal Centre of the Royal Astronomical Society of Canada, a group with a long history of introducing people to the stars. The telescope was aimed at Albireo and the group's leader, Isabel Williamson, began to explain the orbits of double stars.

"Oh yes," the observer interrupted helpfully, "I can see them revolving now."

"I doubt that," Miss Williamson replied. "The period of revolution is 600 years!"

Below: ***One of the richest open clusters in the sky is Scutum's M11, located in the heart of the Scutum star cloud. A 4-inch telescope trained on M11 shows dozens of bright stars arranged in a triangular shape. Photo by Martin C. Germano, who used an 8-inch f/5 reflector, hypered Tech Pan film, and a 30-minute exposure.***

Below left: ***Bisected by a broad dust lane and peppered with the bright stars of cluster NGC 6530, the Lagoon Nebula in Sagittarius is one of the summer Milky Way's grandest treats. Photo by David Healy, who used a 14-inch SCT at f/7, hypered Tech Pan film, and a 24-minute exposure.***

Double Stars

First, let's go back to that double I proudly split with the naked eye — **Epsilon Lyrae**. It is a wide, beautiful double, both members of which shine at about 4.5 magnitude. If your telescope has 4-inches' aperture or more and the seeing is good, you should be able to split this double-double a second time and resolve each of the two stars into their two components. All four stars appear white.

Summer is an especially good time for double star aficionados. You may discover some of them for yourself simply by sweeping your telescope through the starfields around Beta Cygni looking for close pairs. Then you can move to the sky's other prominent doubles, from **Gamma (γ) Leonis** and **Gamma Virginis** in the west. **Alpha Librae** is wide enough that it can be separated in binoculars, as are **Mu (μ)** and **Nu (ν) Scorpii**, and **Kappa (κ) Herculis**.

Omicron (ο) Cygni, has 4th-magnitude yellow and 5th-magnitude blue components that are fainter versions of the Beta Cygni system. **Alpha Capricorni**, far to the southeast of Cygnus, is the widest double in the summer sky. The stars, of 3.6 and 4.3 magnitude, are not physically connected. However, each star is itself a double that is resolvable with a small telescope. **Beta (β) Capricorni** is also an easy double.

Variables

For patient observers, discovery can occur with single stars that vary in brightness over time. In the eighteenth century, John Goodricke, a deaf person whose silent universe was shared with just a few friends, discovered **Beta Lyrae** was a variable star that changed in brightness by a magnitude every fortnight. Beta Lyrae is an eclipsing binary, a double star with a fainter component that passes in front of the brighter, causing the change in magnitude. (By circumstance, we happen to

Left: ***M13, the Hercules Cluster, is one of the finest globulars in the sky. A 4-inch scope resolved this cluster's edges into stars, and a 6-inch instrument shows hundreds of stars across the cluster's face. Photo by Martin C. Germano, who used an 8-inch f/10 SCT, 103a-F film, and a 20-minute exposure.***

Right: ***The most planetary nebula of them all, Lyra's Ring Nebula, is visible all summer. Its oval, ringlike shape is easy to see even in a 3-inch telescope, but spotting the elusive central star requires a 12- or 16-inch telescope and a black, steady night. Photo by Paul Roques, who used an 8-inch f/10 SCT and hypered Tech Pan film.***

be nearly in the star's orbital plane and thus see these stellar eclipses.)

Later in the night you may see Delta in Cepheus, another variable discovered by Goodricke. **Delta (δ) Cephei** changes from magnitude 3.6 to 4.3 every 5 days and 9 hours. This discovery was monumental, for Delta's variation is intrinsic and real: it comes from a process occuring within the star; it's not simply an accident of geometry like Beta Lyrae. It was also a sad discovery, because in his efforts to observe it Goodricke developed pneumonia and died at the age of twenty-one. Before many of us have opened our eyes intellectually, John Goodricke had discovered a universe and was dead.

Eta (η) Aquilae in the eastern wing of the Eagle is another such variable, a Cepheid that changes from magnitude 4.1 to 5.3 every 7.2 days.

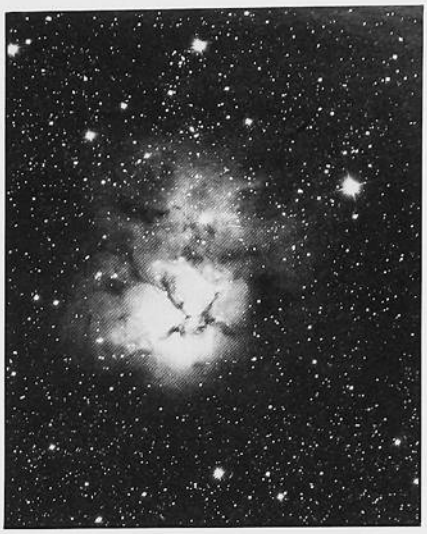
Deep-Sky Objects

A year after I separated Epsilon Lyrae, I "discovered" **M31**. The sky was clear but hazy. (My suburban backyard never offered really fine viewing conditions.) I followed my star map and, sure enough, the galaxy appeared as a dimly luminous smudge just where it was supposed to be.

Its faint light fostered a sense of mystery. It was a distant blob that had some tantalizing aspect. There wasn't much there — it certainly lacked the detail, the lanes of dust, the myriad star images that the pictures in books always showed. (I have noticed that people at star parties become disappointed when a small telescope doesn't show all the things they've seen in books. Some even abandon their budding interest because the disappointment is so keen. It's crazy, I know.) But in observing you need an imagination, a wish to visualize something that lies beyond what your telescope points out to you.

M31 wasn't much, as I said, but in that elongated fuzz I imagined all the incredible detail that larger telescopes have since shown me. My small telescope didn't matter because even my childhood view had a sense of size and distance no textbook photograph could ever match. It was a view I have never forgotten.

Yet with **M13** in Hercules small telescopes can offer wonders if the optical quality is good. This mighty globular cluster is at least 34,000 light-years away, its 100,000 stars orbiting our Galaxy in a tightly packed ball. In my first look with a 3.5-inch reflector I sensed myriad stars although I could not resolve them. I needed an 8-inch reflector and a trip to dark skies (summer camp in the Adirondacks) before I finally saw this cluster resolved into its multitudinous stars. M13 is the Northern Hemisphere's best, but another nearby globular cluster is almost as good: M92, also in Hercules, offers a more compact structure and is visible in small scopes.



Above right: ***Just 2.5° north of the Lagoon Nebula is another spectacular emission nebula called M20. Because trisecting dark lanes float in front of this nebula, M20 is nicknamed the Trifid Nebula. The fainter, oval nebulosity to the north shines by reflection and is bluish in color photographs. Photo by Al Lilge, who used a 12.5-inch f/8 Pro Scope, 098 film, and a 120-minute exposure.***

Above: ***Though it was traditionally thought a difficult object to observe visually, the faint supernova remnant called the Veil Nebula in Cygnus is within the grasp of small scopes. Observe the two brightest sections of it on a clear, dark night, preferably with a good nebula filter. Photo by Al Lilge, who used a 4-inch f/6 astrographic lens, 098 film, a 75-minute exposure, and an orange filter.***

Summer along the Milky Way

The Milky Way, our home Galaxy seen edge-on, features many of the sky's best sights, and summer is the ideal season to explore them. High overhead, right next to Beta Lyrae, is the **Ring Nebula** (M57). It is a cosmic smoke ring, the remains of a star that expelled part of its atmosphere in an explosion long ago.

In neighboring Cygnus, a few degrees south of Epsilon Cygni, we can see the aftermath of an even more violent explosion. This is the **Veil Nebula** (NGC 6960 and 6992-5), the wispy remnant of a star that exploded as a supernova at least 50,000 years ago.

Moving further south, we approach the Galaxy's center and witness magnificent star clusters like **M11** in Scutum, a marvellous configuration of hot blue suns. Farther south still, we begin to meet the clouds of hydrogen gas that fill Sagittarius with emission nebulae. M8 is called the **Lagoon Nebula** because of a dark, dusty path within. The **Trifid Nebula** (M20) has a threefold complexity brought out best by dark skies.

My favorite, however, is yet another — nearby M17, the **Omega Nebula**. Try to look at this one from a dark sky using at least an 8-inch telescope because it is truly a fine sight. The nebula's delicate strands challenge your imagination as you try to understand the processes at work in creating something so exquisite.

The role these emission nebulae play is one of creation, for here new stars are being formed. This part of the Galaxy is relatively young, and the stars that shine here may be as young as a few million years. As we look at these nebulae, we cross an ocean of space to see a beginning.

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Tucson, AZ 85747

Double Stars

The Top Ten Double Stars

by Glenn F. Chaple

I cannot tell a lie. The response to my "Top Ten Doubles" request, put forth in this column a year ago, wasn't exactly overwhelming. In fact, only about a dozen readers sent in lists of their favorite pairs. To these dedicated observers I send my heartfelt thanks.

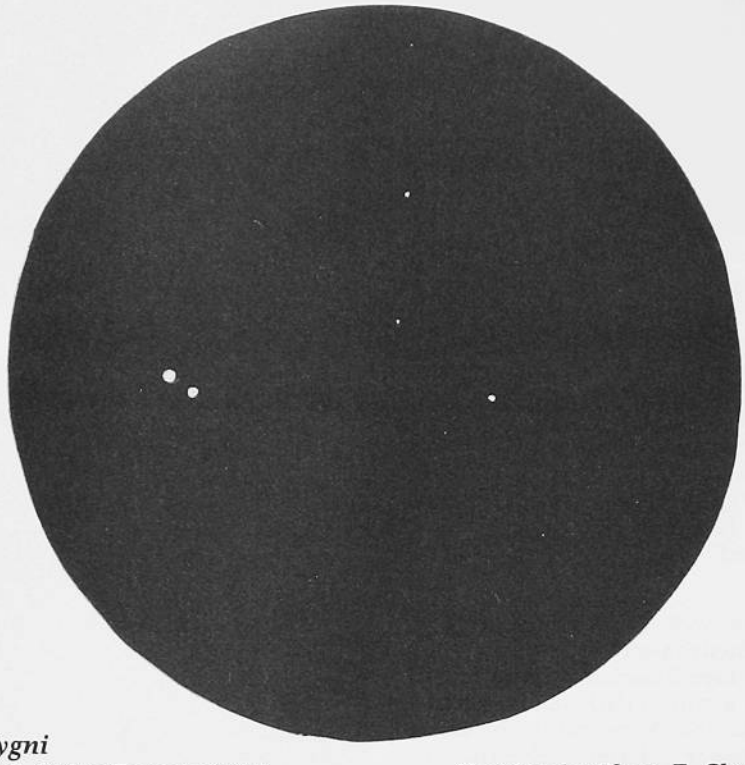
I could have tallied the results to produce a Top Ten list and then padded the numbers to make it appear as though several hundred eager readers had mailed in lists of their favorite doubles. Instead, Honest Glenn will combine these results with those of a similar survey conducted in 1978 to produce an updated Top Ten list. Here are the results.

1. (30 votes) Beta (β) Cygni, **Albireo**

One glance at this beautiful double star and you'll see why it was the favorite of the readers who responded to the survey. Wide and bright, Albireo is an easy target for any telescope. Its celebrated colors — golden yellow for the primary, deep blue for the companion — have caused many a first-time observer to gasp in amazement.

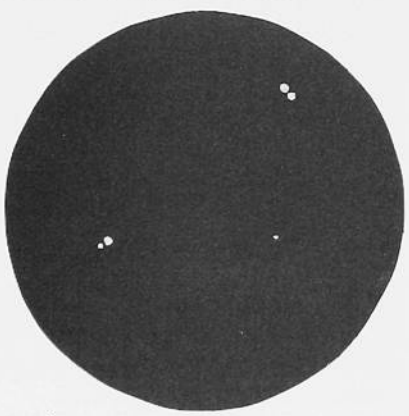
2. (25) **Epsilon (ε) Lyrae**

The renowned "Double-Double" lies

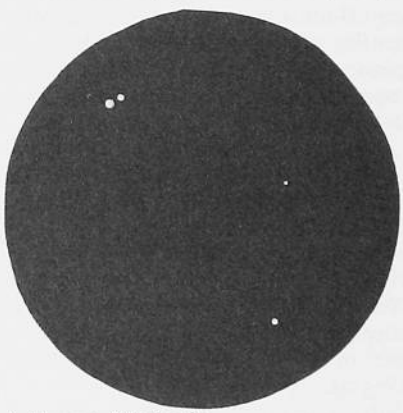


β Cygni
3-inch f/10 reflector at 60x

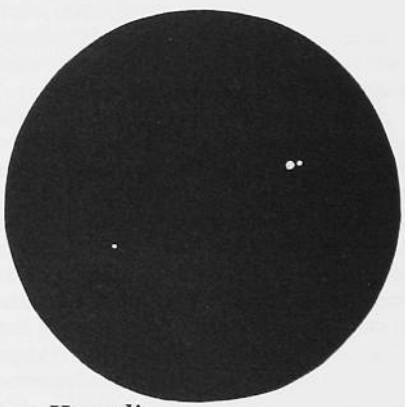
Sketches by Glenn F. Chaple, Jr.



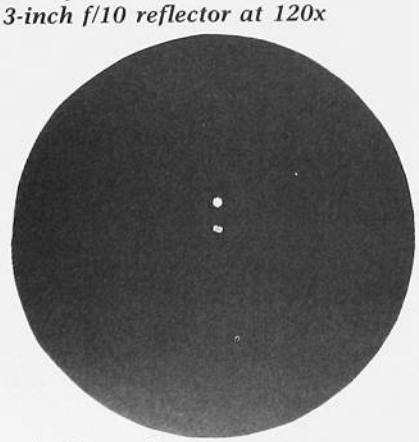
$\varepsilon^{1,2}$ Lyrae
3-inch f/10 reflector at 120x



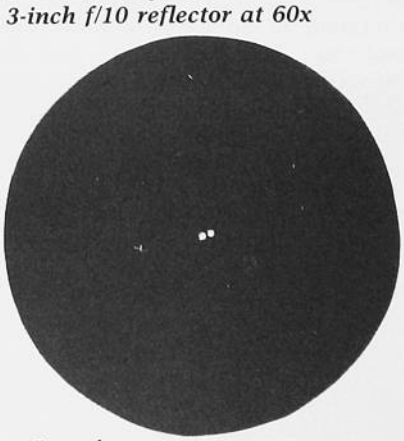
ζ Ursae Majoris
3-inch f/10 reflector at 60x



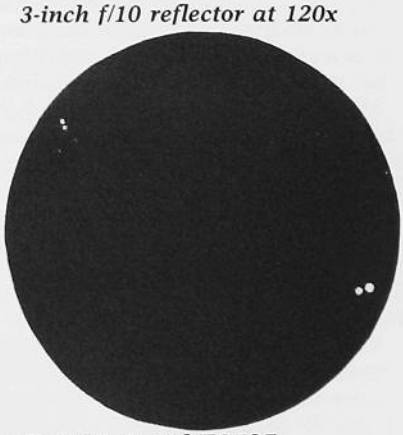
α Herculis
3-inch f/10 reflector at 120x



γ Andromedae
6-inch f/15 refractor at 360x



γ Leonis
3-inch f/10 reflector at 120x



γ Delphini and Σ2725
3-inch f/10 reflector at 60x

about 2° east of Vega. Good eyesight (or binoculars) will make the first "split," and all four stars may be glimpsed in a 3-inch scope provided the seeing is good or better and you use a magnification of at least 100x. The two pairs are separated by 208."

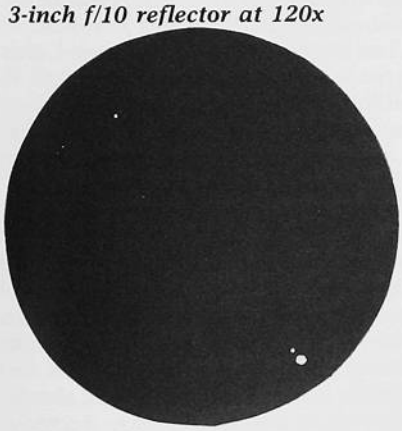
3. (18) Gamma (γ) Andromedae, **Almach**

Like Albireo, Almach is a striking gold and blue pair. This may sound like heresy, but I favor this pair over Albireo because its component stars lie closer together. The fainter star is a close binary (5.5 and 6.3 magnitude, separation = 0.6", position angle = 106°, 1987) that will challenge viewers with an 8-inch scope.

4. (16) Zeta (ζ) Ursae Majoris, **Mizar**

Because Mizar is the middle star in the handle of the Big Dipper (where the handle bends), it is one of the easiest double stars to locate. That, plus its brightness and wide separation, make it an ideal double for the beginner. This system was the first double star to be identified and also the first one found to be a spectroscopic binary. (Both components are spectroscopic binaries, in fact.) Alcor, which lies in the same field of view at low power, is another spectroscopic binary and has the same proper motion as Mizar — though the space separation between the two star systems is about a quarter of a light-year, or some 2.5 trillion kilometers.

α Geminorum
3-inch f/10 reflector at 120x



α Ursae Minoris
3-inch f/10 reflector at 60x

5. (15) Gamma (γ) Leonis, **Algieba**

This slow-moving yellow binary has a period estimated at between 600 and 700 years. It is a nice sight at 100x, appearing like car headlights seen from a distance.

6. (12) Alpha (α) Herculis, **Rasalgethi**

I think you'll enjoy the fine contrast between the orange-red primary and its blue-green companion. The main star varies irregularly between 3rd- and 4th-magnitude.

7. (11) **Gamma (γ) Delphini**

This pretty double forms the Dolphin's snout. Can you detect a slight color contrast between the component stars? In the same field is the faint pair Struve 2725 (7.6 and 8.4, 5.8", 8°, 1959).

8. (10) Alpha (α) Geminorum, **Castor**

This binary pair is currently widening from a minimum separation of 1.8" (1969). Both stars are white and accompanied at a distance of 72.5" (p.a. 164°) by a reddish 9th-magnitude star. All three components are spectroscopic binaries, which makes Castor a sextuple star!

9. (9) Alpha (α) Ursae Minoris, **Polaris**

A classic light test for small scopes. If you can't see the companion, try high power and averted vision. With a 6-inch or larger telescope, you'll see the pair's contrasting yellow and blue colors. Polaris is also a Cepheid variable with a 4-day period and a visually undetectable range of only 0.1 magnitude.

10. (8) **Theta^1 (θ^1) Orionis**

The "Trapezium" is located in the heart of the Orion Nebula. This is perhaps the finest multiple star in the night sky. Several fainter companions may be glimpsed in 6-inch or larger scopes.

(8) **Sigma (σ) Orionis**

Another fine multiple star that reveals something with every kind of optical aid from binoculars to the largest telescope. Sigma isn't widely known as a "showpiece," but it's splendid all the same. In the same field, 3-1/2' northwest is the faint triple Struve 761.

(8) Gamma (γ) Virginis, **Porrima**

A binary system that is slowly closing toward 0.4" separation in 2008. Both components are yellowish.

* * *

DOUBLE TAKES: Last December veteran double star observer Herman Fast passed away at the age of seventy-two. To regular readers of *Deep Sky*, Mr. Fast is no stranger. He was a dedicated double star observer who frequently contributed items of interest to this column. During a fifty-five year span he "recorded" well over 10,000 double and multiple stars, plus a multitude of Messier and NGC objects. Besides being a diligent observer, he was a telescope maker and a founding member of the San Francisco Amateur Astronomers. Declining health didn't keep Mr. Fast away from the hobby that was his life and love, though. He remained active to the end — he attended a board meeting of the SFAA the night before his death.

As it happened, our paths didn't cross so I never had the luck to meet him, but through a steady correspondence we did become good friends. I miss him, and so do the many amateur astronomers in the Bay Area who knew and loved him.

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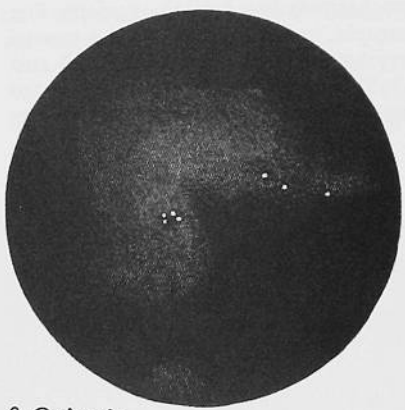
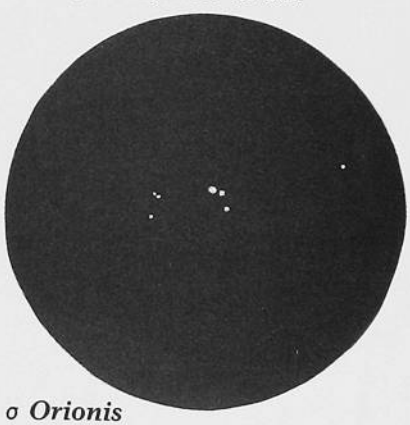
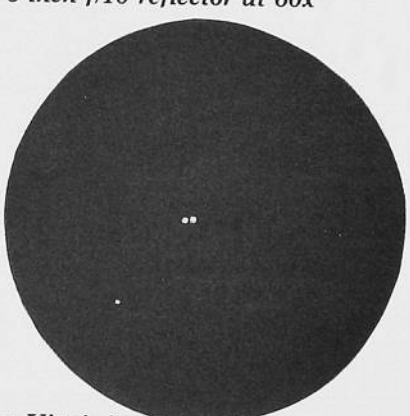


θ Orionis
3-inch f/10 reflector at 60x



σ Orionis
3-inch f/10 reflector at 60x



γ Virginis
3-inch f/10 reflector at 120x

Variable Stars

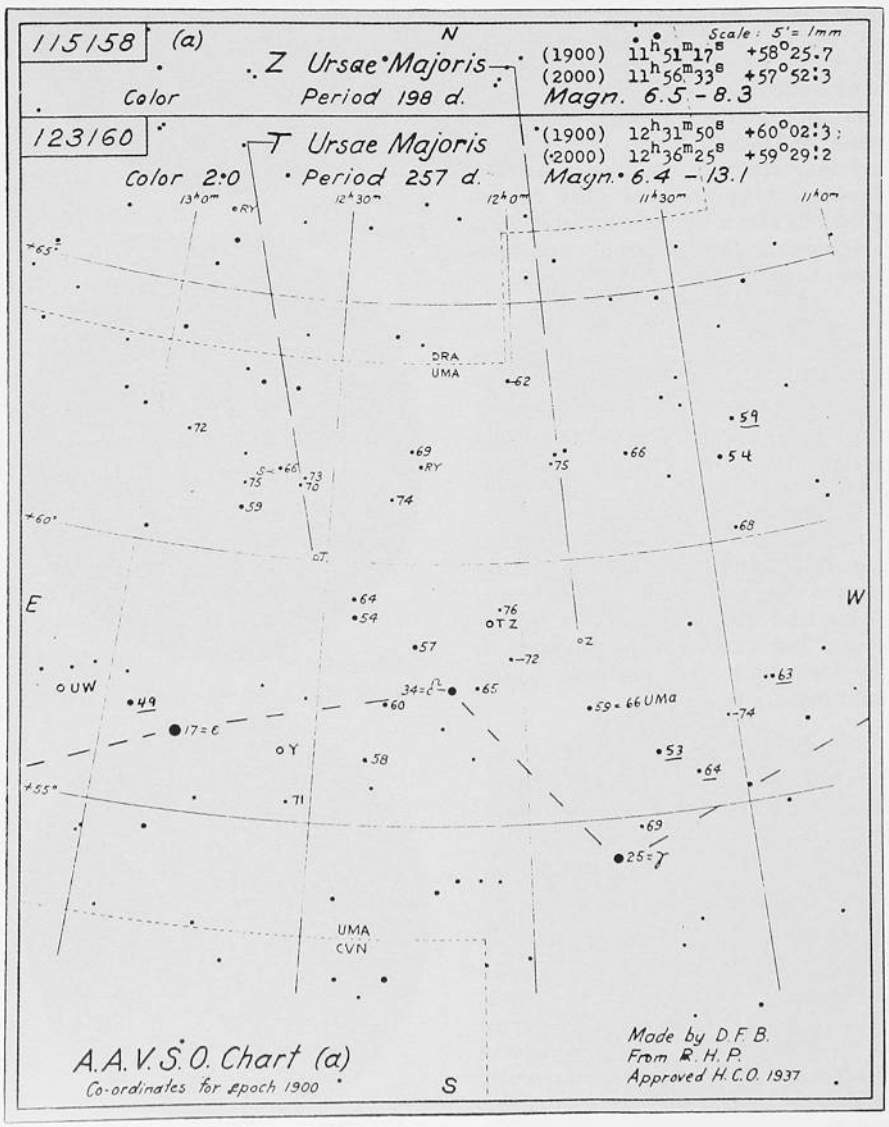
How to Estimate a Variable's Brightness

by David H. Levy

A huge, evolved, red giant star, **Z Ursae Majoris**, is displaying some unusual behavior in the late stages of its life. Although it is relatively bright and thus reasonably well observed, it can surprise in ways that textbooks in their armchair wisdom tend to overlook. For example, some sources list the star as varying between magnitudes 6.5 and 8.3. Yet I have seen it drop to 9.5, more than a full magnitude below its "normal" minimum.

Unlike those grand clocks, the Mira stars, which have a strong, repeatable rhythm in their variations, Z UMa has enough differences from one period to the next that we call it a semiregular variable. But even the semiregulars themselves are subdivided. VZ Camelopardalis, for instance, has a rough period of 24 days, but Betelgeuse slowly pulsates over 5.7 *years*.

A lot of the bright variables we turn our telescopes toward belong to the class of semiregulars. In fact, a glance through a catalogue of variable stars will show many such stars with variations ranging from 5th- to 7th-magnitude. These stars appear relatively bright because they are supergiants with as much as a thousand times the Sun's diameter and many times its luminosity.



Estimating Z UMa's Brightness

Look closely at the two accompanying charts. The one on the left is designed to be used with binoculars, so it has an upright (north at top) orientation. The other chart is meant for telescopes and has south at top. (If you're using either a Schmidt-Cassegrain scope or a refractor and a star diagonal, your view has south at top, but left and right are reversed. Make a photocopy of the telescopic chart, turn it over, and look at its blank reverse side while illuminating the chart from behind.)

In the binocular chart you'll recognize the Big Dipper; near the top of the bowl is the circle-and-dot symbol that marks the variable's position. Next to selected other stars are numbers like 66, 54, and 64. These numbers show magnitudes and tenths of comparison stars. The decimal points have been omitted to rule out any chance of your confusing them with faint stars. You should read 66 as 6.6 magnitude, and so on.

If you look at the area with binoculars and can locate Z UMa easily, then use the left chart. Look at Z carefully and compare it to the nearby stars. Is Z brighter than magnitude 5.9 but fainter than 5.4? If not, does it fall between 5.9 and 6.4? Or between 5.9 and 6.6? Let's say a careful look tells you that it lies between magnitudes 5.9 and 6.4. (If it were exactly as bright as 5.9, then you'd naturally log it as that. If Z UMa were just slightly fainter than 5.9, you'd call it 6.0.) Now it gets a little tricky, however, for you have to determine just where between 5.9 and 6.4 it lies. If it is about midway between the limits but slightly closer to 5.9, then you note the magnitude as 6.1. If it's closer to 6.4, then record 6.2. If it is almost as faint as 6.4, its brightness is 6.3.

You have just made an estimate of a variable star in the same way some 4 million others have since 1911. You may even have found it easy to do. Or it could have been a nightmare.

Perhaps Z UMa wasn't where the chart showed it should be. In that case you need the telescopic chart. First, make certain your finder scope is aligned with the main scope's optical axis. Find and center any bright star in a medium power eyepiece. Then look through the finder and twiddle its adjuster screws until the bright star is centered in the finder. (Now recheck the main eyepiece in case the scope drifted.)

American Association of Variable Star Observers (2)

With Z UMa, aim the finder so the magnitude 5.9 comparison star lies right in the middle. With a low power eyepiece in the main scope, locate the 5.9 star again and then work your way past the 8.8, the 9.0, and the 8.6 stars to Z itself. This will take some time, so be patient! Once you locate Z, the process goes as outlined above: find two comparison stars that straddle Z in brightness and determine where Z's magnitude lies relative to them. Try to keep the stars near the center of the field of view when you determine their brightnesses — this produces more accurate estimates.

This method is one of several ways to estimate a variable's brightness. In my judgment it's also the simplest. But here are some others.

Fractional Method

The fractional method's great virtue is that it works without having any predetermined magnitudes for the comparison stars. Thus, you can use it if you know a particular variable star and have either forgotten your chart with its comparison magnitudes or you spot a new bright star (a nova, say) for which there is no chart.

You simply choose two stars, again straddling the variable in brightness. Determine where the variable is in brightness between them. For example, if the variable lies three-fourths of the way (in brightness, remember!) between comparison stars A and B, you would log the variable as "A,3,V,1,B".

A raw observation like this must be reduced — converted to an actual magnitude. After making the observation, we look up the comparison stars on our chart or in a star catalogue. Let's say A is magnitude 8.6 and B is 9.0, so the difference is 0.4 magnitude. Since we observed that the variable was three-fourths of the magnitude difference from A to B, we divide the total magnitude difference by 4. This yields 0.1 magnitude as the "basic unit." (Had we used another fraction, we would have divided the magnitude difference by the appropriate amount and derived a different basic unit.) Our logbook says the variable was three basic units dimmer than A and one basic unit brighter than B. Or $8.6 + (3 \times 0.1) = 8.9$. Checking from B we get $9.0 - (1 \times 0.1) = 8.9$. Never forget that magnitude numbers increase as you go dimmer!

The Herschel-Argelander Method

This system uses "steps," which are defined as the smallest difference between two stars that your eye can distinguish. Before you consider the variable star at all, you establish brightness steps among the comparison stars: 0 if two stars are equal in brightness, 1 if there is a small but perceptible difference, 2 if the difference is more pronounced, and so on. As you become more experienced — and this method requires a lengthy "breaking-in" period for the observer — the value of the step will likely settle down close to 0.1 magnitude.

Pogson's Step Method

This procedure differs from the previous one in that each step is precisely 0.1 magnitude. It involves comparing a variable with a single comparison star using a previously memorized interval of 0.1 magnitude. You then observe the variable again using a different comparison star. The variable's actual magnitude is reduced from your logbook's notes.

Your first observation, say, might tell you that relative to comp star A, the variable was one step (0.1 magnitude) fainter. This is logged as "A+1". In your next observation, using a fainter comp star, you note that the variable is four steps (0.4 magnitude) brighter than the comp star, noting it as "B-4". In the reduction stage you look up the magnitudes of A and B and find that A = 8.6 and B = 9.1. Then 8.6 + 0.1 = 8.7 and as the check, 9.1 − 0.4 = 8.7 also.

Pogson's Mixed Method

A variation that comes close to what many observers do is the "Pogson mixed method." In this system you know ahead of time what the magnitude interval between the two comparison stars is — let's say 8.6 and 9.0 —and that the variable lies between them in brightness. You determine that the variable is one step dimmer than the 8.6 star and then independently determine how many steps brighter it is than the 9.0 star. If the answer doesn't tally, redo it.

The details of any one method actually matter less than your becoming thoroughly familiar with whatever method you choose. Find one you can do well and use it until it becomes second nature.

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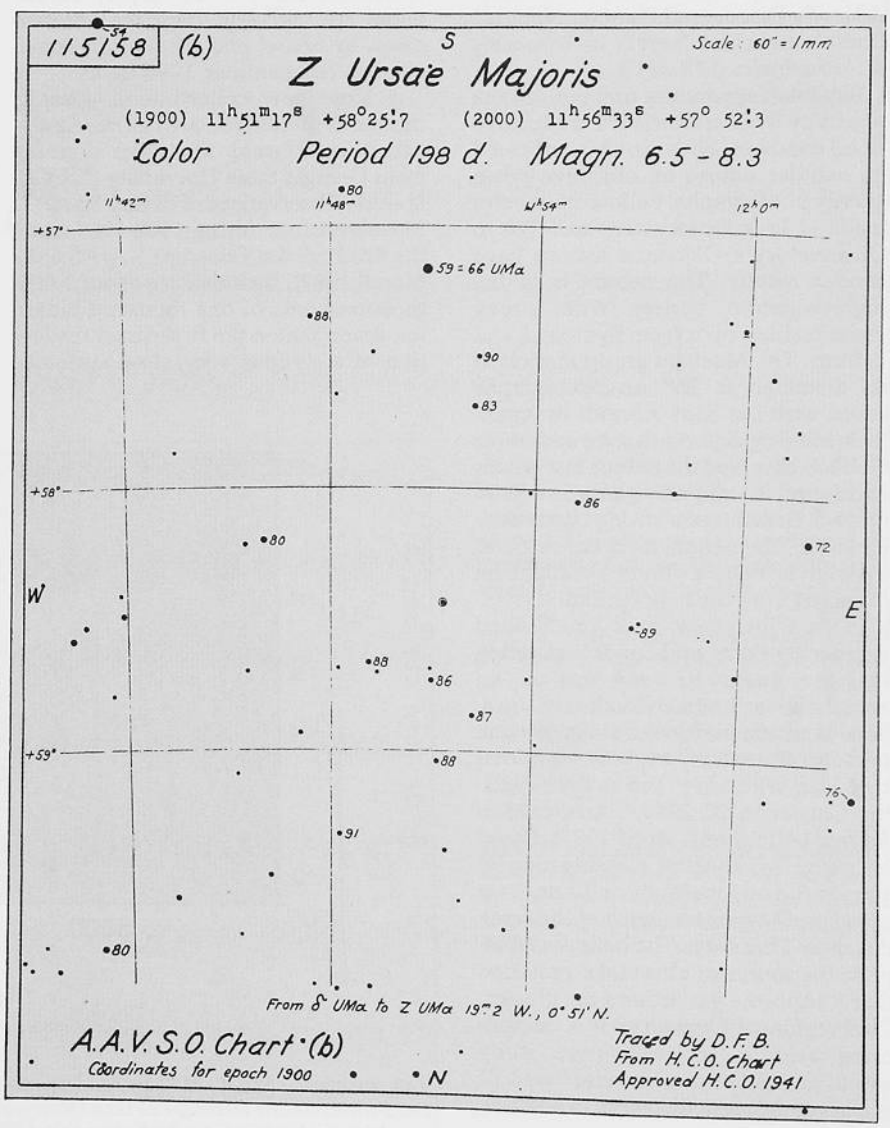

Scanning the Literature

January — June 1987
by Brian Skiff

The identity and nature of one more NGC object has been resolved by two groups working independently. NGC 2242, a 15th-magnitude object in Auriga (2000 coordinates: 6h34.2m, +44°47′) was catalogued as a galaxy after its discovery by Lewis Swift in 1886. (Swift discovered this object visually with a 16-inch refractor.) However, the object has been shown to be an unusual planetary nebula by Richard Shaw and William Bidelman ("NGC 2242: A Newly Discovered Planetary Nebula," *Publications* of the Astronomical Society of the Pacific, [*PASP*] **99**:27, January 1987) and a group of Japanese and Chinese astronomers led by H. Maehara ("NGC 2242: A Newly Discovered Plantary Nebula" [there's an echo in here!], in *Astronomy & Astrophysics* **178**:221.)

Bidelman apparently first noticed the object by its characteristics in the large *IRAS* database; both groups confirmed its nebular nature on objective-prism survey photographs. Follow-up spectra made at Lick Observatory and Tokyo Observatory's Okayama station gave similar results. The nebula is of the high-excitation variety with strong emission lines of oxygen, hydrogen, and helium. The Maehara group measured its diameter as 26″ on photographs taken with the Kiso Schmidt in Japan. Jack Marling reports that he and Steve Gottlieb observed the nebula last winter and found it to be about magnitude 14 or 14.5. Because of a strong continuum emission, the nebula does not respond as well to nebula filters as might be expected from the high excitation level.

In the Winter 1986 issue I mentioned a paper by Perry and Landolt claiming that the cluster IC 2944 was not an actual cluster but a collection of unrelated hot stars positioned along our line of sight. A contrary view is supported by Nolan Walborn ("The O-Type Ionizing Cluster in IC 2944," *Astronomical Journal* [*AJ*] **93**:868, April 1987). Based on extensive spectral classification of stars in the region, Walborn finds there are eight O-type stars lying at the same distance. These stars, he believes, comprise the source of ultraviolet radiation that ionizes the gas around the cluster. This region of Centaurus is a complicated area: a comprehensive study would probably reveal several "layers" of stars at different distances in addition to the main cluster.

Rather more definitive is a new proper-motion study of the bright globular Messier 2 by Kyle Cudworth and Bernard Rauscher ("Astronomy and Photometry in the Globular Cluster M2," *AJ* **93**:856, April 1987). The two astronomers measured plates taken with the Yerkes 40-inch refractor in 1900, 1978, and 1985. Proper motions and BV photographic photometry to V magnitude 16 are provided for three hundred stars in the field.

The long time-baseline of the plates and the large image scale of the telescope yielded excellent separations of field stars, which have large motions relative to cluster members. This is because cluster members are practically fixed on the sky because of their great distance. The authors note an improved position for the center of the cluster: 21h33m27.0s, −0°49′23″ (2000). This is about 30″ different from the number given by Shawl and White in a paper cited in the Summer 1986 issue.

A large new collection of speckle measures of double stars has been published by Harold McAlister's group from Georgia State University ("ICCD Speckle Observations of Binary Stars. II. Measurements during 1982-1985 from the Kitt Peak 4m Telescope," *AJ* **93**:688, March 1987). Included are about 2,800 measurements of one thousand binaries, among them the first direct resolution of sixty-four very close systems. This extensive list concentrates on very close pairs but gives recent data for dozens of doubles accessible in 6- to 10-inch telescopes.

Two sets of magnitude sequences useful to amateur observers and astrophotographers have been published recently. "UBVR Sequences in M31 and M33" by Roberta Humphreys and Michael and Annamaria Sitko, *PASP* **99**:380, May 1987) gives photoelectric sequences of stars in fields of these two bright galaxies. Precise coordinates and finder charts are provided for the several dozen stars, which range from V magnitude 10 to 19. These should be especially useful to observers hunting for normal novae in these objects.

The other paper by Gonzalo Alcaino, William Liller, and Franklin Alvarado gives sequences of bright stars around eight southern globular clusters ("Photoelectric UBVRI Sequences in the Region of the Galactic Globular Clusters NGC 288, 1851, 1904, 4590, 4833, 5946, 6139, 7099," *AJ* **93**:1464, June 1987). Finder charts of each cluster are included to identify the stars, which range from magnitude 10 to 15. Although sequences have been previously published for all these clusters, the data here extend them to the standard red and infrared wavelengths.

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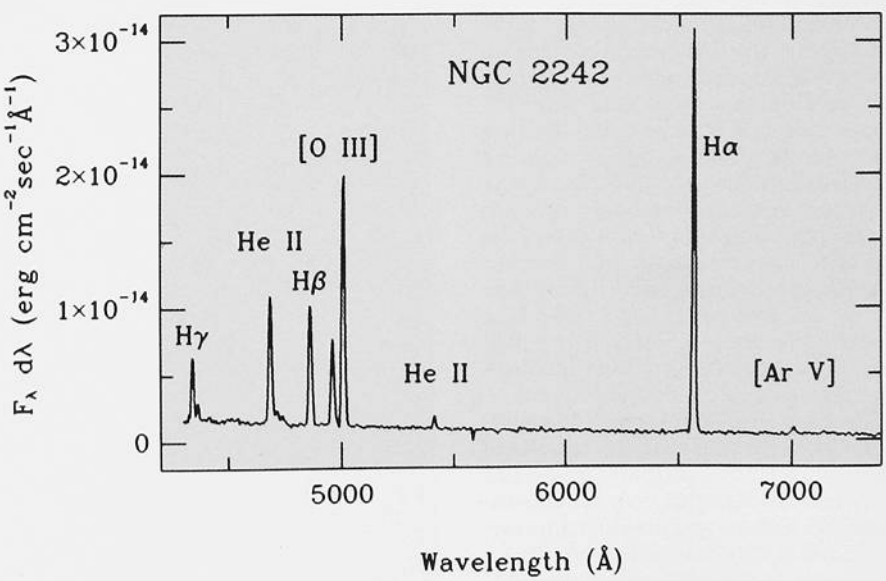
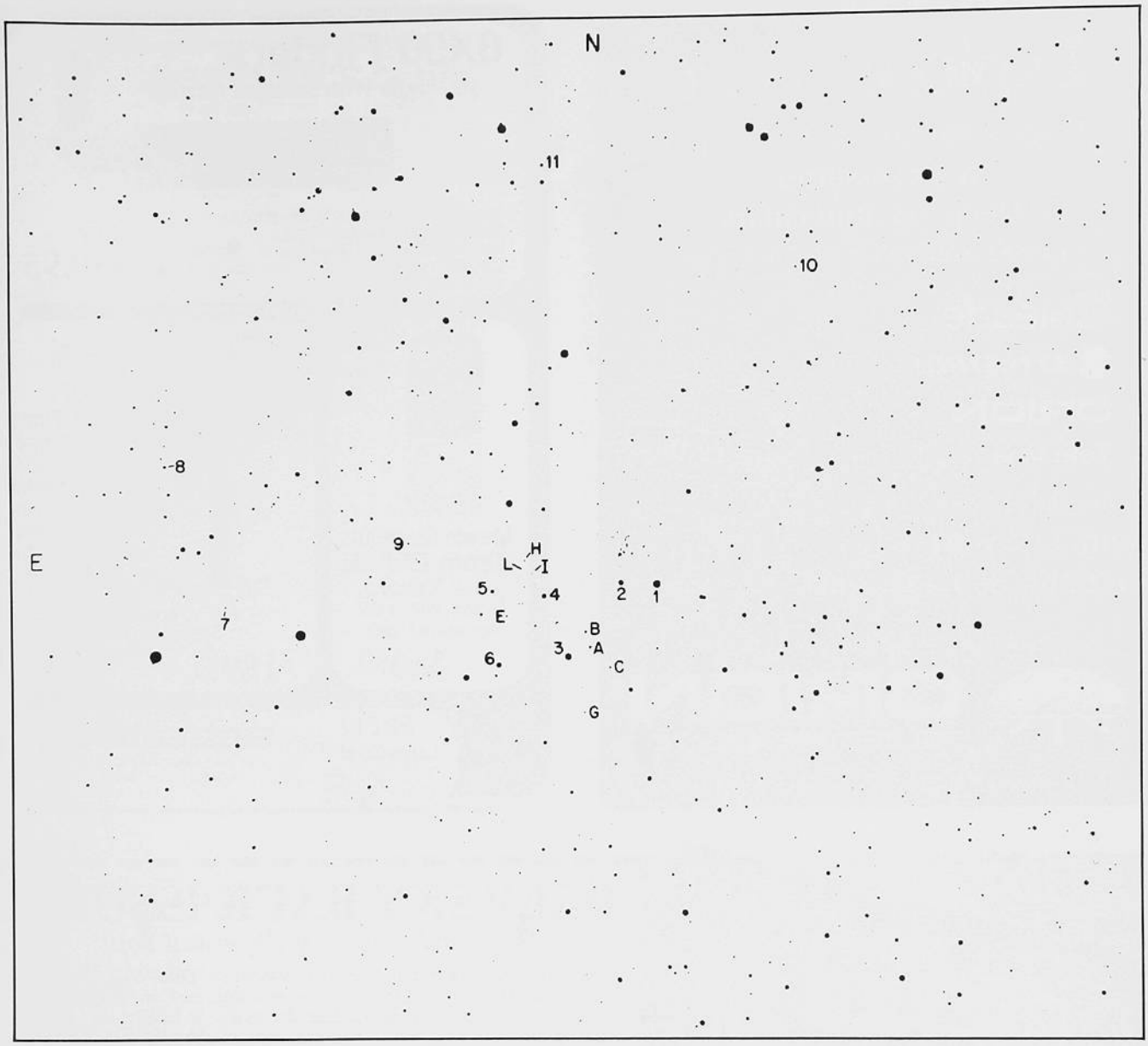
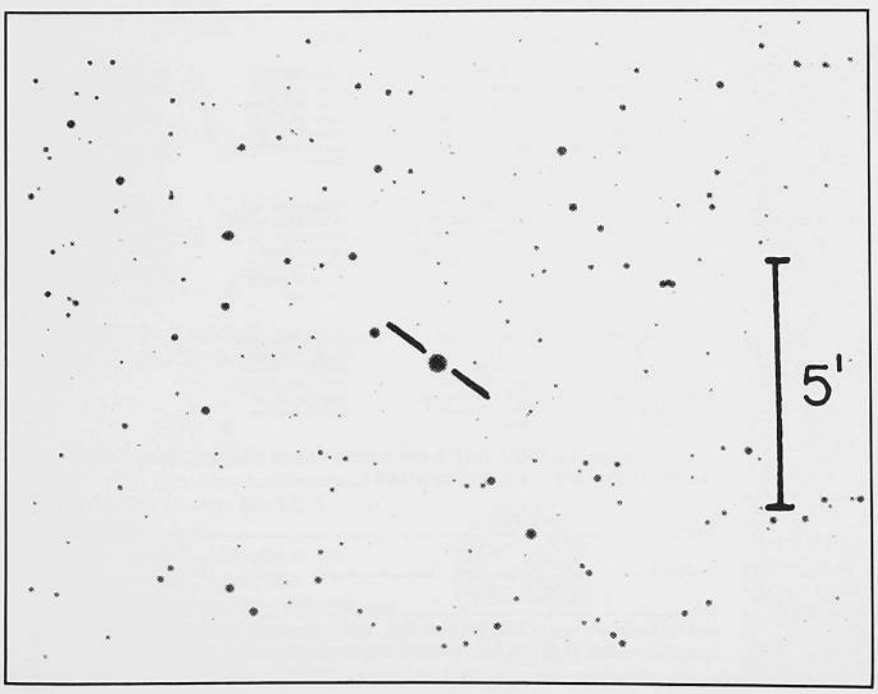


The spectrum of NGC 2242 in Auriga, made by astronomers Shaw and Bidelman with the 3-meter Shane telescope at Lick Observatory. The spectrum indicates a nonredshifted, very high ionization gas, which shows that NGC 2242 is an extremely hot planetary nebula. From Shaw and Bidelman, PASP.





Above: *Finding chart for stellar magnitudes in Baade and Swope's M31 Field IV about 1.5° southwest of the nucleus of the Andromeda Galaxy. The V magnitudes of numbered and lettered stars are as follows: 1: 11.3; 2: 12.6; 3: 11.8; 4: 13.6; 5: 14.7; 6: 13.5; 7: 16.8; 8: 15.2; 9: 16.1; 10: 16.3; 11: 14.9; A: 15.5; B: 16.0; C: 16.3; E: 16.4; G: 17.1; H: 17.4; I: 17.4; L: 18.8. Readers may wish to use this field to detect limiting magnitudes for determining limiting visual and photographic magnitudes. From Humphreys, Sitko, and Sitko,* PASP.

Left: *The unusual planetary nebula NGC 2242 enlarged from the* POSS *with north up and east to the left. Palomar Observatory photograph from Shaw and Bidelman,* PASP.

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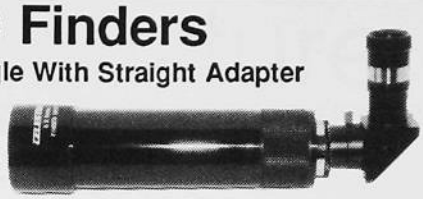

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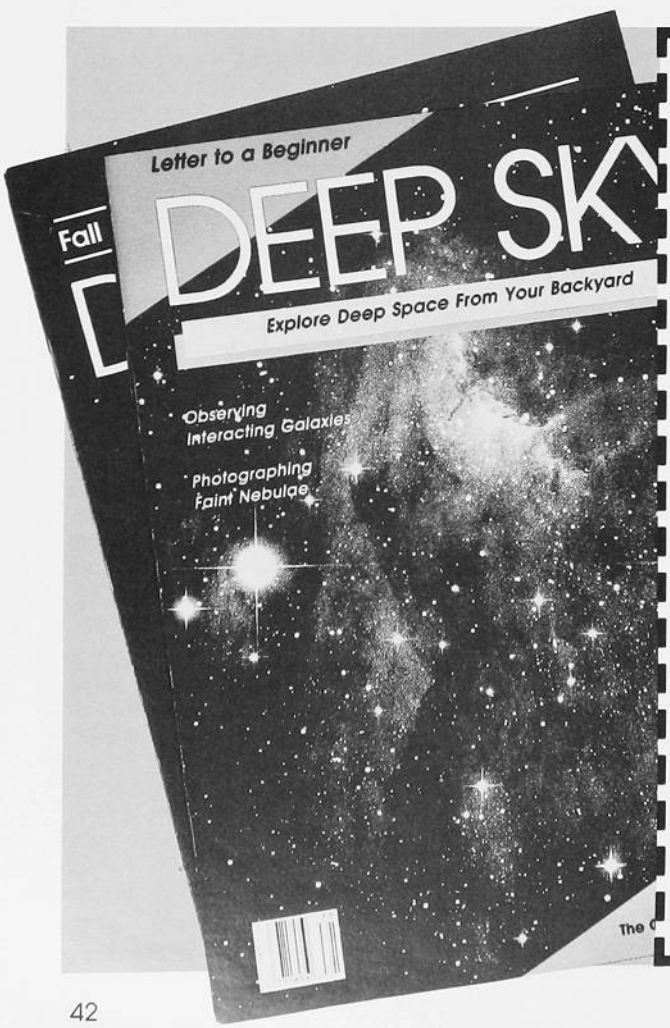

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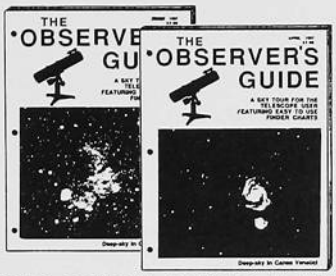

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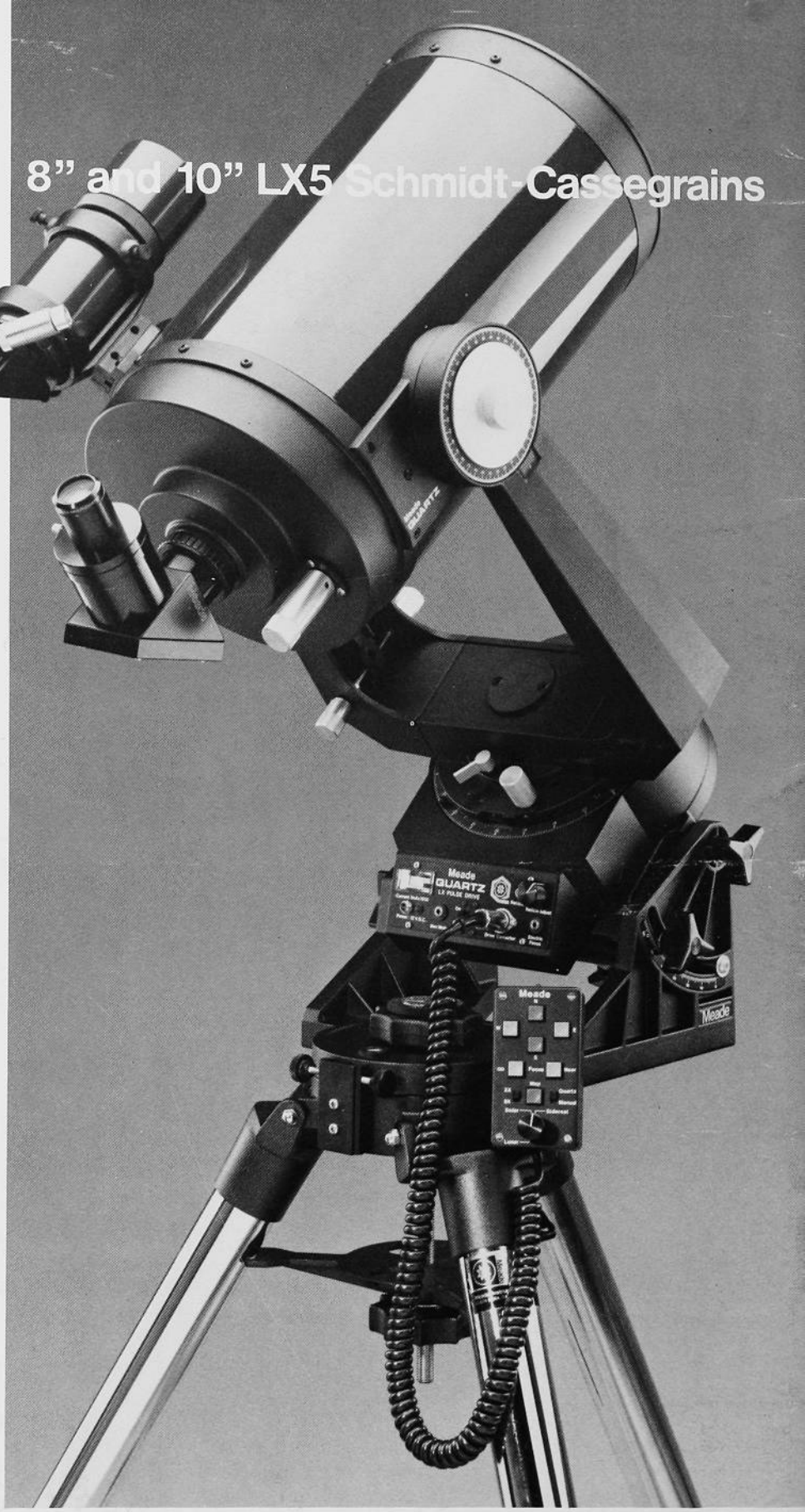

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